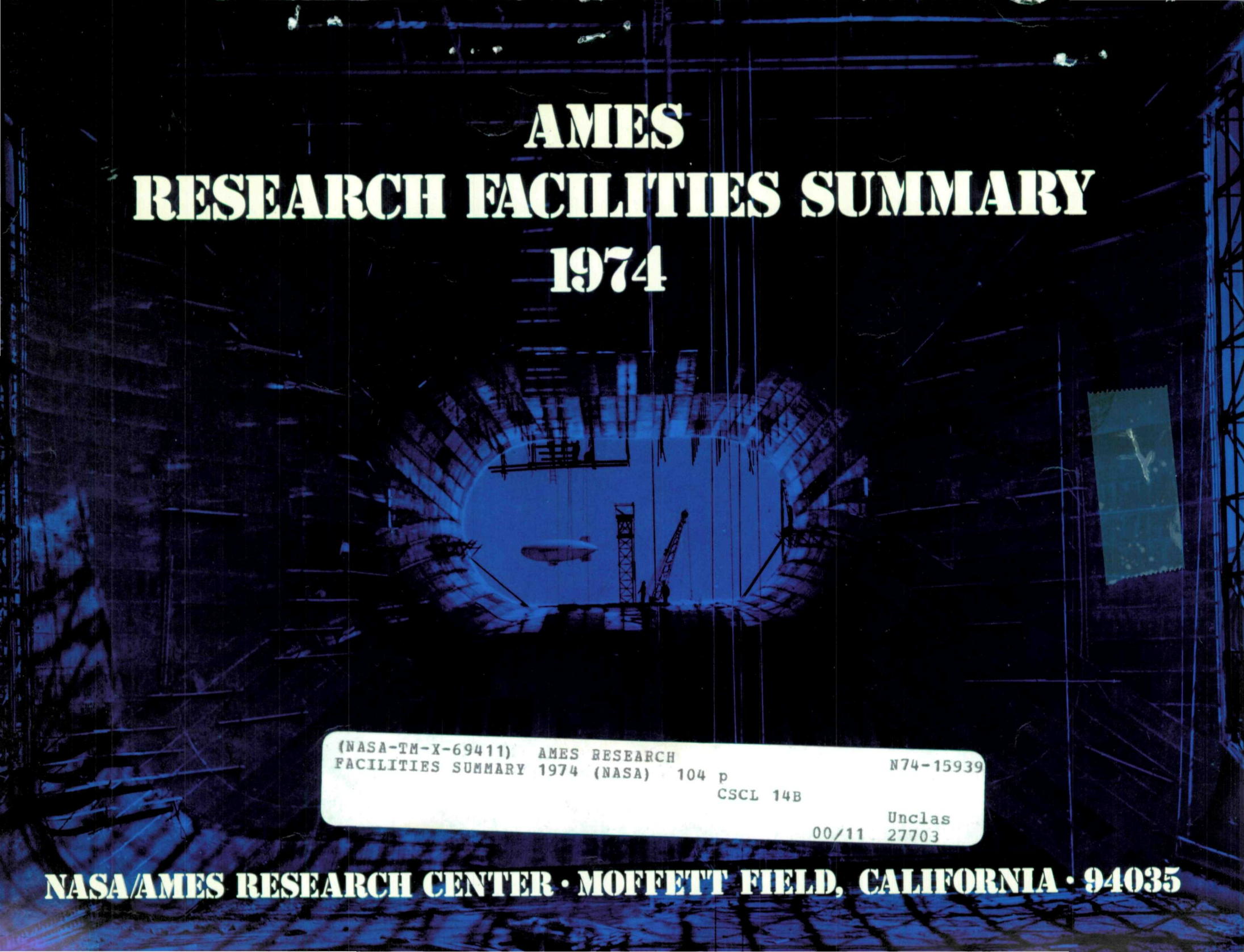
AMES RESEARCH FACILITIES SUMMARY 1974



(NASA-TM-X-69411) AMES RESEARCH FACILITIES SUMMARY 1974 (NASA) 104 p
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NASA/AMES RESEARCH CENTER · MOFFETT FIELD, CALIFORNIA · 94035

FOREWORD

Ames Research Center, a field installation of the National Aeronautics and Space Administration, was established in 1940 and is located at the southern end of San Francisco Bay on land contiguous to the U.S. Naval Air Station, Moffett Field, California. Its physical plant comprises some thirty-four major technical facilities and laboratories that are used as research tools in the aeronautical, physical, space, and life sciences. The Center occupies 365 acres of land and uses runway facilities and certain other utilities jointly with the Department of the Navy. Based on initial costs, the capital investment in the Center is approximately $270 million.

Ames' strength lies in the expertise of its staff of scientists, engineers and technicians together with the highly specialized, sometimes unique, facilities necessary to perform programs of national importance. This book is a summary of selected facilities at Ames focusing on (1) Subsonic, Transonic, and Supersonic Wind Tunnels; (2) High Enthalpy and Hypersonic Wind Tunnels, Shock Tubes and Ballistic Ranges; (3) Flight Simulators: (4) Research Aircraft; and (5) Computers.

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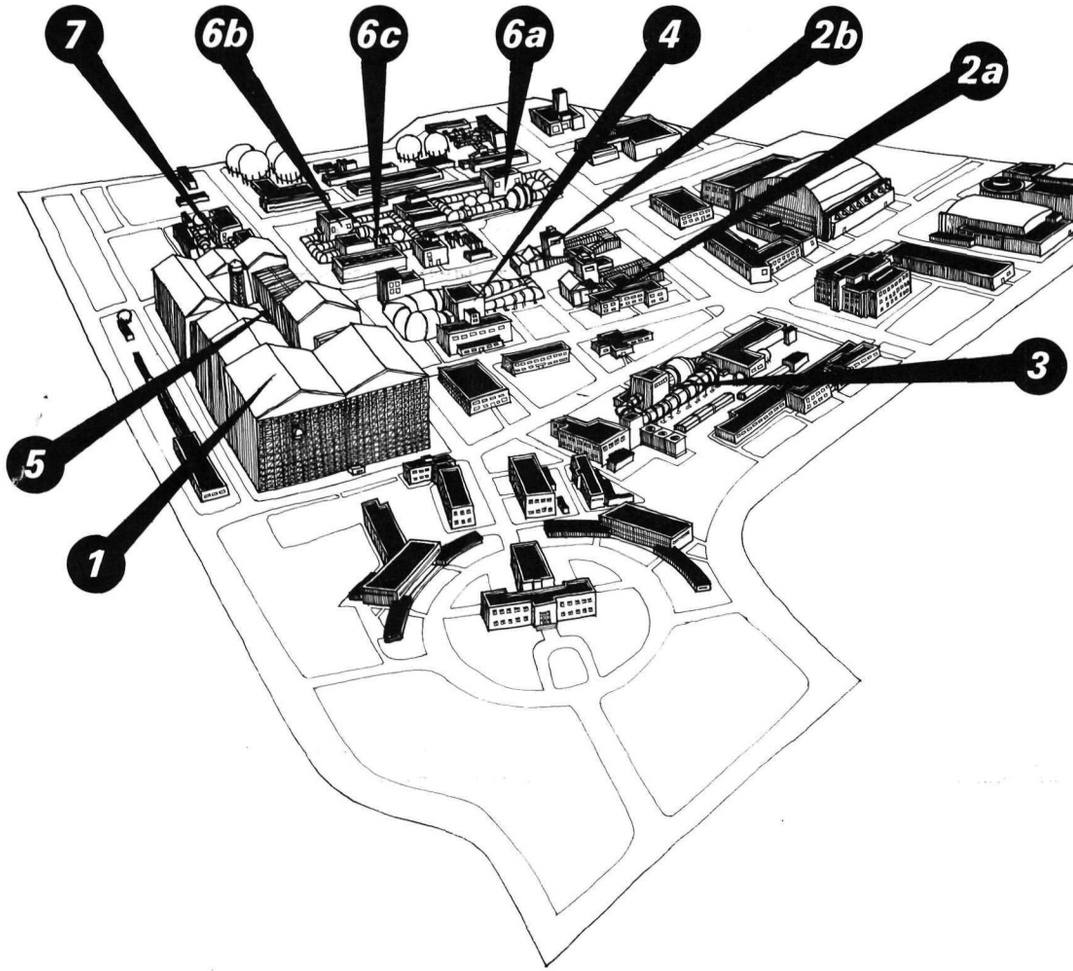


1. WIND TUNNELS

(SUBSONIC, TRANSONIC, SUPERSONIC)

1. *FORTY-BY EIGHTY-FOOT WIND TUNNEL*

2a. *SEVEN-BY TEN-FOOT WIND TUNNEL NO. 1*

2b. *SEVEN-BY TEN-FOOT WIND TUNNEL NO. 2 (AAMRDL)*

3. *TWELVE-FOOT WIND TUNNEL*

4. *FOURTEEN-FOOT WIND TUNNEL*

5. *TWO-BY TWO-FOOT WIND TUNNEL*

6. *UNITARY PLAN WIND TUNNELS*

6a. *ELEVEN-BY ELEVEN-FOOT WIND TUNNEL*

6b. *NINE-BY SEVEN-FOOT WIND TUNNEL*

6c. *EIGHT-BY SEVEN-FOOT WIND TUNNEL*

7. *SIX-BY SIX-FOOT WIND TUNNEL*

1. WIND TUNNELS

SUBSONIC
TRANSONIC
SUPERSONIC

1. FORTY-BY EIGHTY-FOOT SUBSONIC WIND TUNNEL

DESCRIPTION:

The Forty- by Eighty-Foot Subsonic Wind Tunnel is a closed-throat, closed-circuit wind tunnel used primarily for determining the low-speed aerodynamic characteristics of high-performance aircraft and spacecraft (particularly landing and take-off and V/STOL aircraft and rotorcraft). Airflow is produced by six, variable speed, 40-foot-diameter fans, each powered by a 6,000 horsepower electric motor.

Power for operation of propellers, etc., can be obtained from either aircraft engines or electric motors. Either gasoline or JP-type fuel can be supplied for internal-combustion engines in the test section. A variety of electric motors are available for model propulsion systems (maximum electric power available for these is 3,000 horsepower).

In addition to a conventional support-strut system, a set of variable-height struts is available for ground proximity studies.

PERFORMANCE:

Speed	0 to 200 knots (continuously variable)
Stagnation Pressure	1.0 atmosphere
Reynolds Number	0 to 2.1 $\times$ 10^6 per foot
Temperature	ambient to 600° R

DIMENSIONS: Test Section

Height	40.0 feet
Width	80.0 feet
Length	80.0 feet
Access	Top doors — 49.0 X 80.0 ft

STATUS:

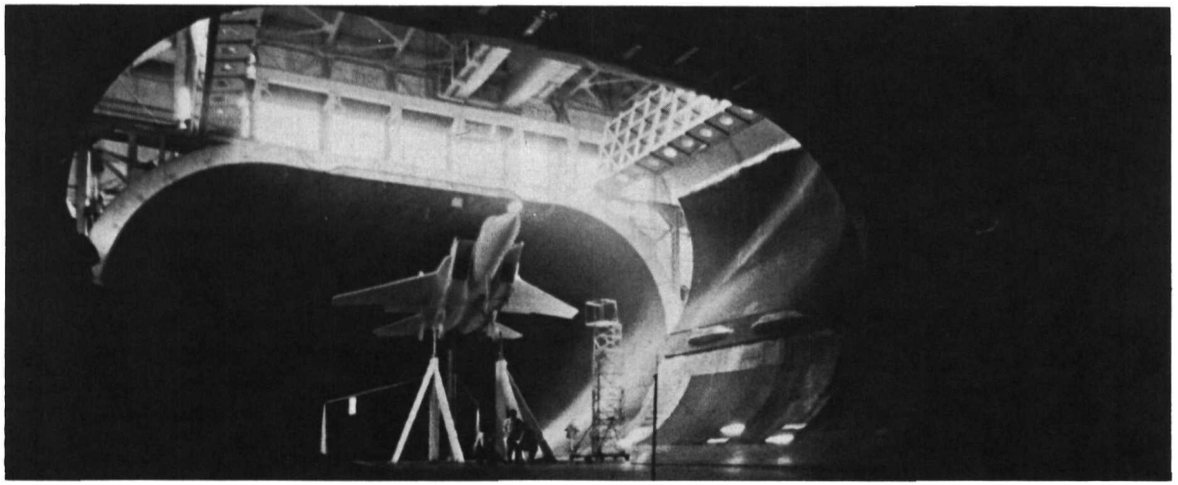
Operational since 1944

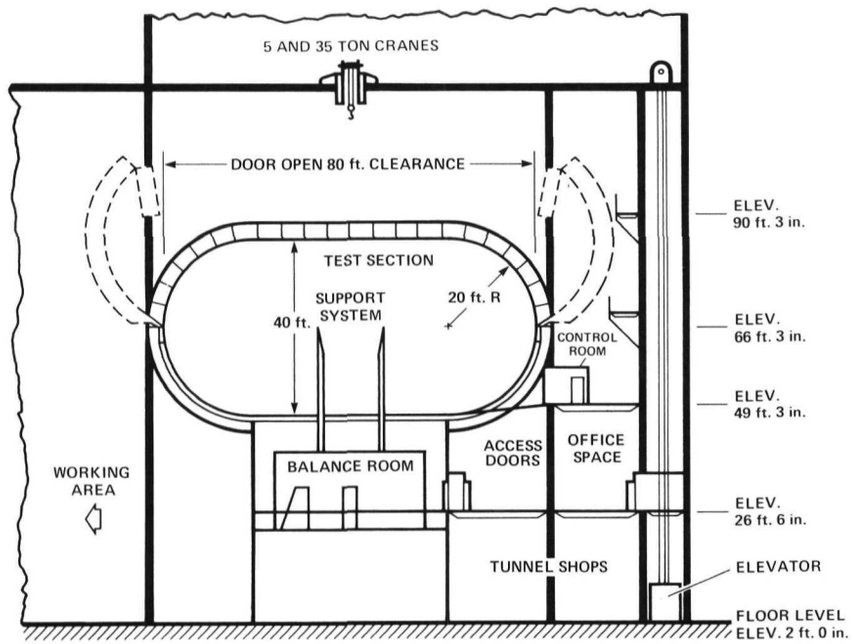
JURISDICTION:

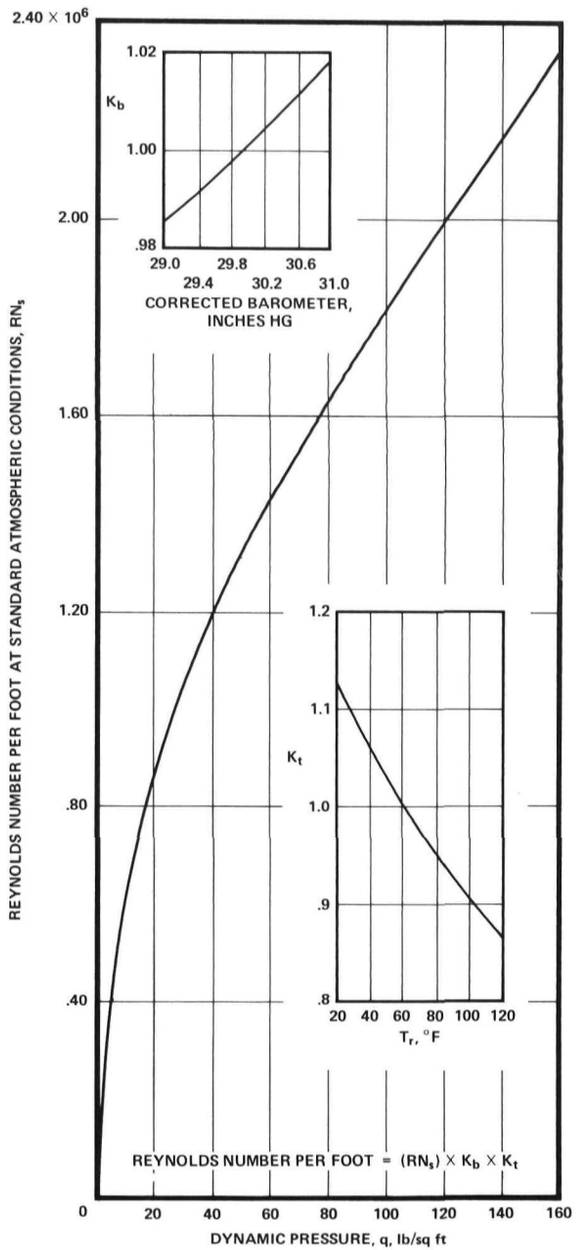
Flight Systems Research Division
Large-Scale Aerodynamics Branch
Mark W. Kelly

LOCATION:

Building N-221




5 AND 35 TON CRANES
DOOR OPEN 80 ft. CLEARANCE
TEST SECTION
SUPPORT SYSTEM
40 ft.
20 ft. R
CONTROL ROOM
ELEV. 90 ft. 3 in.
ELEV. 66 ft. 3 in.
ELEV. 49 ft. 3 in.
WORKING AREA
BALANCE ROOM
ACCESS DOORS
OFFICE SPACE
ELEV. 26 ft. 6 in.
TUNNEL SHOPS
ELEVATOR
FLOOR LEVEL ELEV. 2 ft. 0 in.


2.40 × 10^6
2.00
1.60
1.20
.80
.40
0
REYNOLDS NUMBER PER FOOT AT STANDARD ATMOSPHERIC CONDITIONS, RN_s
1.02
1.00
.98
K_b
29.0
29.4
29.8
30.2
30.6
31.0
CORRECTED BAROMETER, INCHES HG
1.2
1.1
1.0
.9
.8
K_t
20 40 60 80 100 120
T_r, °F
REYNOLDS NUMBER PER FOOT = (RN_s) × K_b × K_t
0 20 40 60 80 100 120 140 160
DYNAMIC PRESSURE, q, lb/sq ft

2a. SEVEN-BY TEN-FOOT SUBSONIC WIND TUNNEL NUMBER 1

DESCRIPTION:

The Seven-by Ten-Foot Subsonic Wind Tunnel (Number 1) is a closed-circuit, atmospheric tunnel. Airflow is produced by a fixed-pitch fan powered by a variable-speed electric motor delivering a total of 1,800 horsepower. Model mounting capabilities include single and dual strut mountings on an external balance, sting mounting using an internal balance, and two dimensional mounts across the seven-foot dimension. Automatic data acquisition equipment (576 active channels plus output of external balance and fixed digital inputs) is located in the test chamber and is linked on-line with an IBM 1800 computer, output data from which is returned to an on-line data plotter in the chamber. Six component measurements can be made for external and sting mounting, as well as three component data for two-dimensional mounting. Data systems include scanivalve and strain-gage conditioning equipment. Various model motors are available with two, 100kw, 400-cycle, variable-frequency power supplies provided, as well as a 3,000 psi air system to power pneumatic drives.

PERFORMANCE:

Speed	0 to 220 knots (continuously variable)
Stagnation Pressure	1.0 atmospheres
Reynolds Number	2.3×10^6 per foot (maximum)
Temperature	~580° R (not controlled)

DIMENSIONS: Test Section

Height	7.0 feet
Width	10.0 feet
Length	16.0 feet
Access	Top hatch – 4.6 X 5.0 feet
	Side doors – 6.3 X 10.0 feet

STATUS:

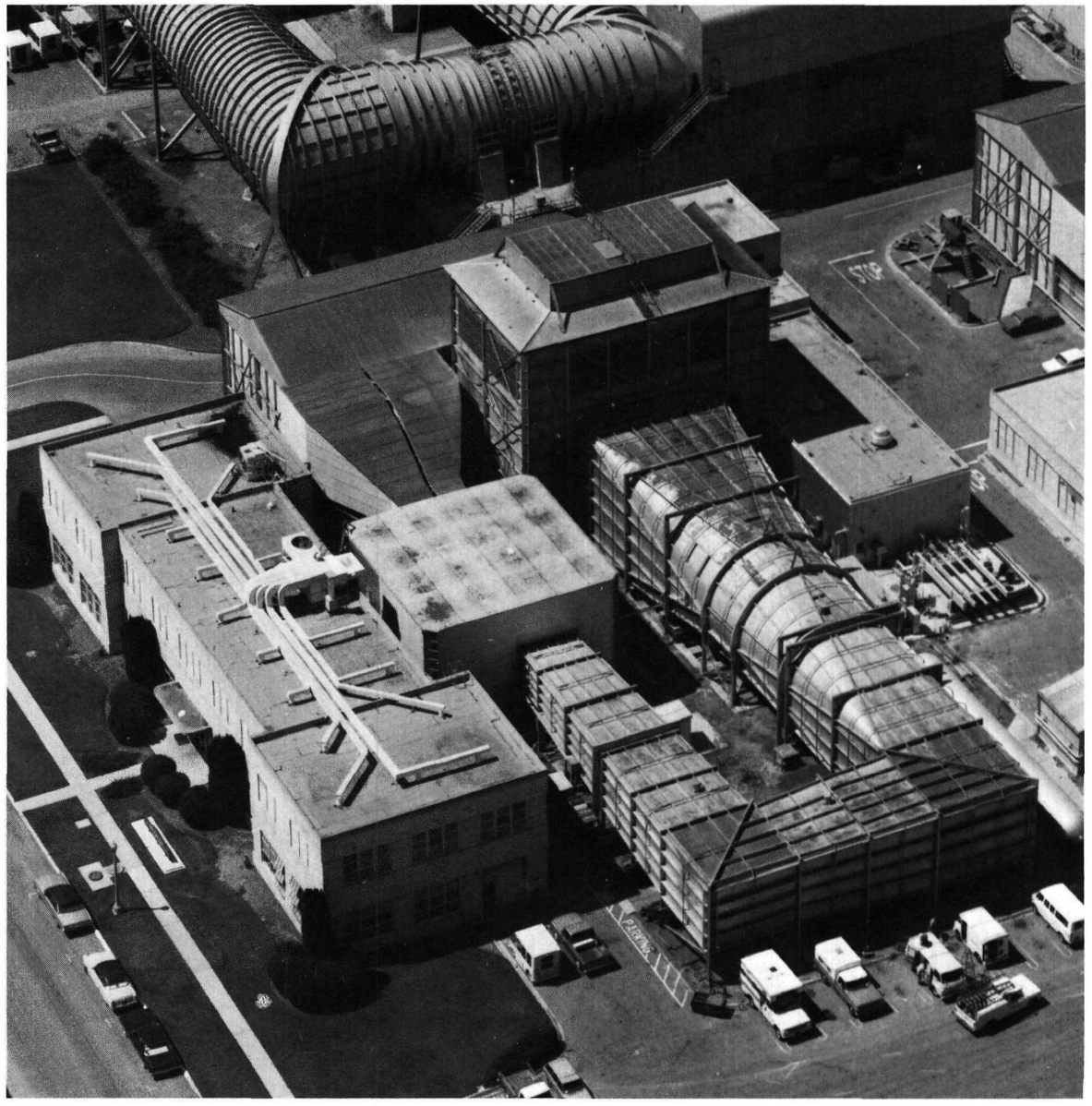
Operational since 1941

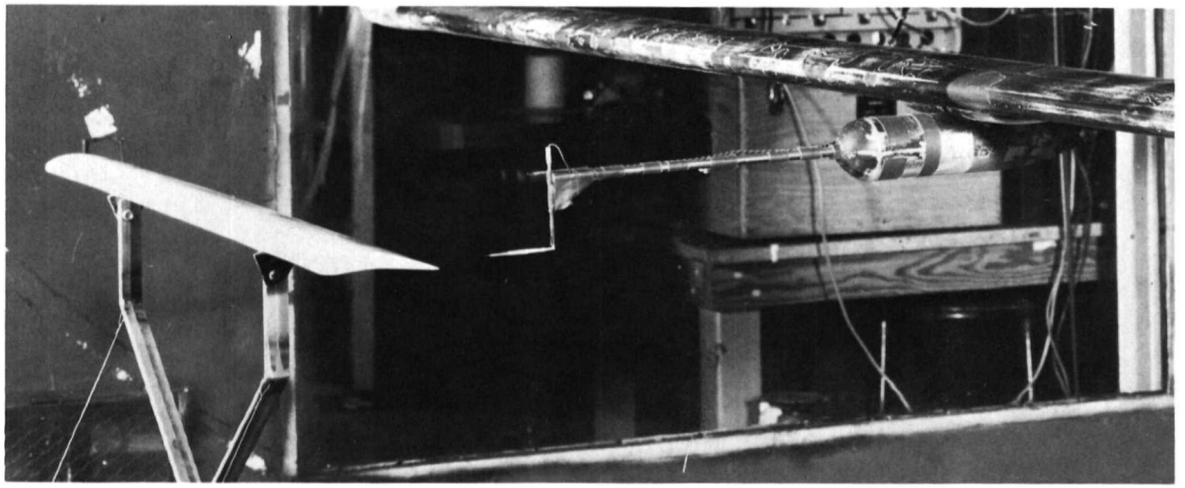
JURISDICTION:

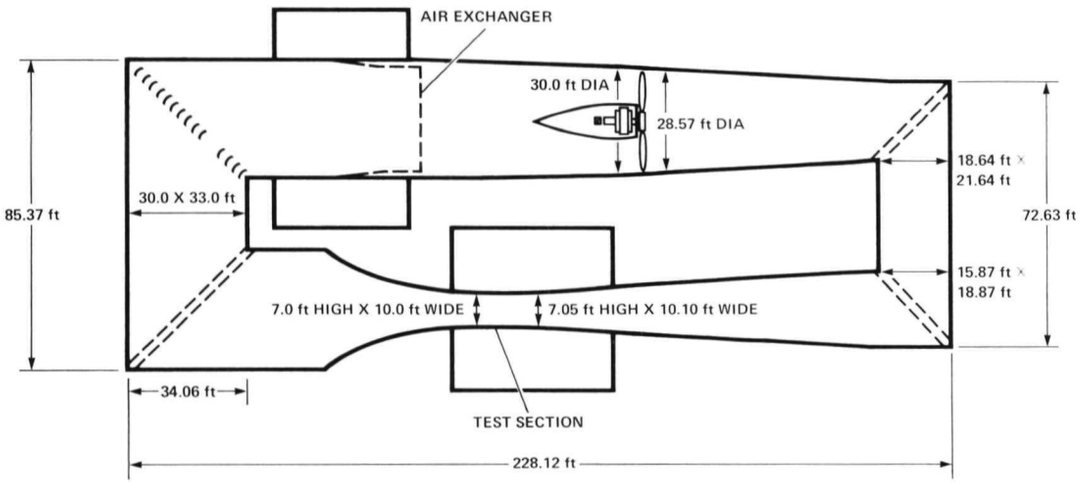
Flight Systems Research Division
Large-Scale Aerodynamics Branch
Mark W. Kelly

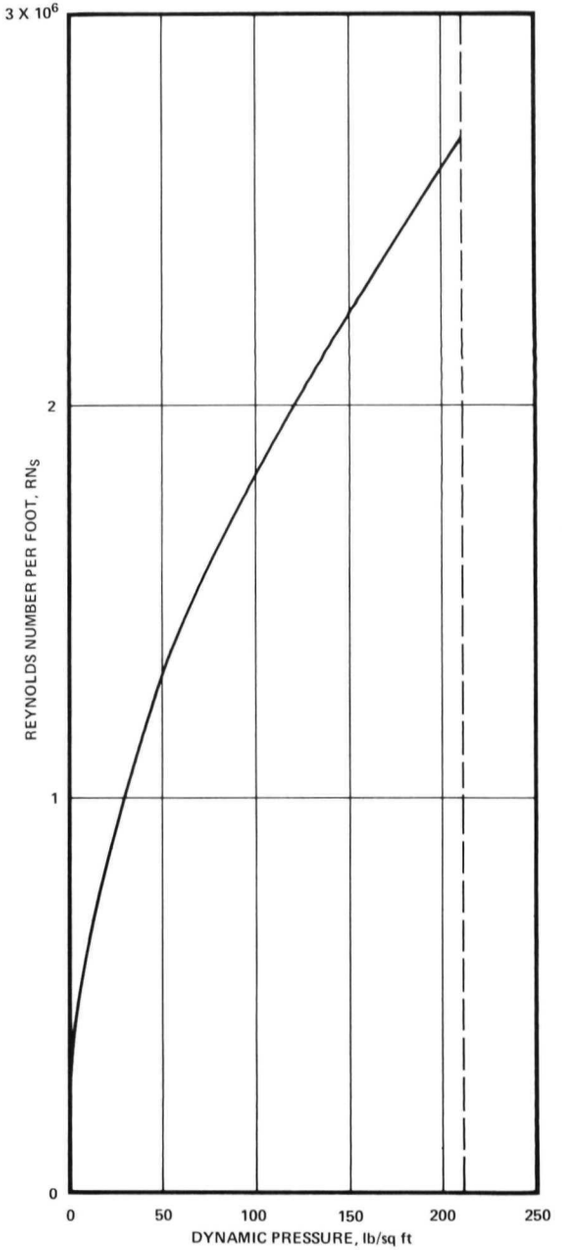
LOCATION:

Building N-215






AIR EXCHANGER
30.0 ft DIA
28.57 ft DIA
18.64 ft
21.64 ft
30.0 X 33.0 ft
85.37 ft
72.63 ft
15.87 ft
18.87 ft
7.0 ft HIGH X 10.0 ft WIDE
7.05 ft HIGH X 10.10 ft WIDE
34.06 ft
TEST SECTION
228.12 ft


3 X 10^6
2
1
0
REYNOLDS NUMBER PER FOOT, RN/ft
0
50
100
150
200
250
DYNAMIC PRESSURE, lb/sq ft

2b. SEVEN-BY TEN-FOOT SUBSONIC WIND TUNNEL NUMBER 2 (AAMRDL)

DESCRIPTION:

The Seven-by Ten-Foot Subsonic Wind Tunnel (Number 2) is a closed-circuit, atmospheric tunnel. Airflow is produced by a fixed-pitch fan powered by a variable-speed electric motor delivering a total of 1,800 horsepower. Test setups are flexible to allow installation of a wide variety of two- and three-dimensional models. Two-dimensional models are installed spanwise with supports at the floor and ceiling of the tunnel; continuous angle-of-attack variation from 0° to 180° is available. Three-dimensional models are generally supported on a single or dual pair of vertical struts, each with a trailing link which provides remote pitch control. Motion in the yaw direction of 360° is available. Various model motors are available with 100kw, 400-cycle, variable-frequency power provided. An external, six-component balance system is used to measure forces and moments

PERFORMANCE:

Speed	0 to 220 knots (continuously variable)
Stagnation Pressure	1.0 atmospheres
Reynolds Number	2.3×10^6 per foot (maximum)
Temperature	~580° R (not controlled)

DIMENSIONS: Test Section

Height	7.0 feet
Width	10.0 feet
Length	16.0 feet
Access	Top hatch – 4.8 feet diameter
	Side door – 6.3 × 10.0 feet

STATUS:

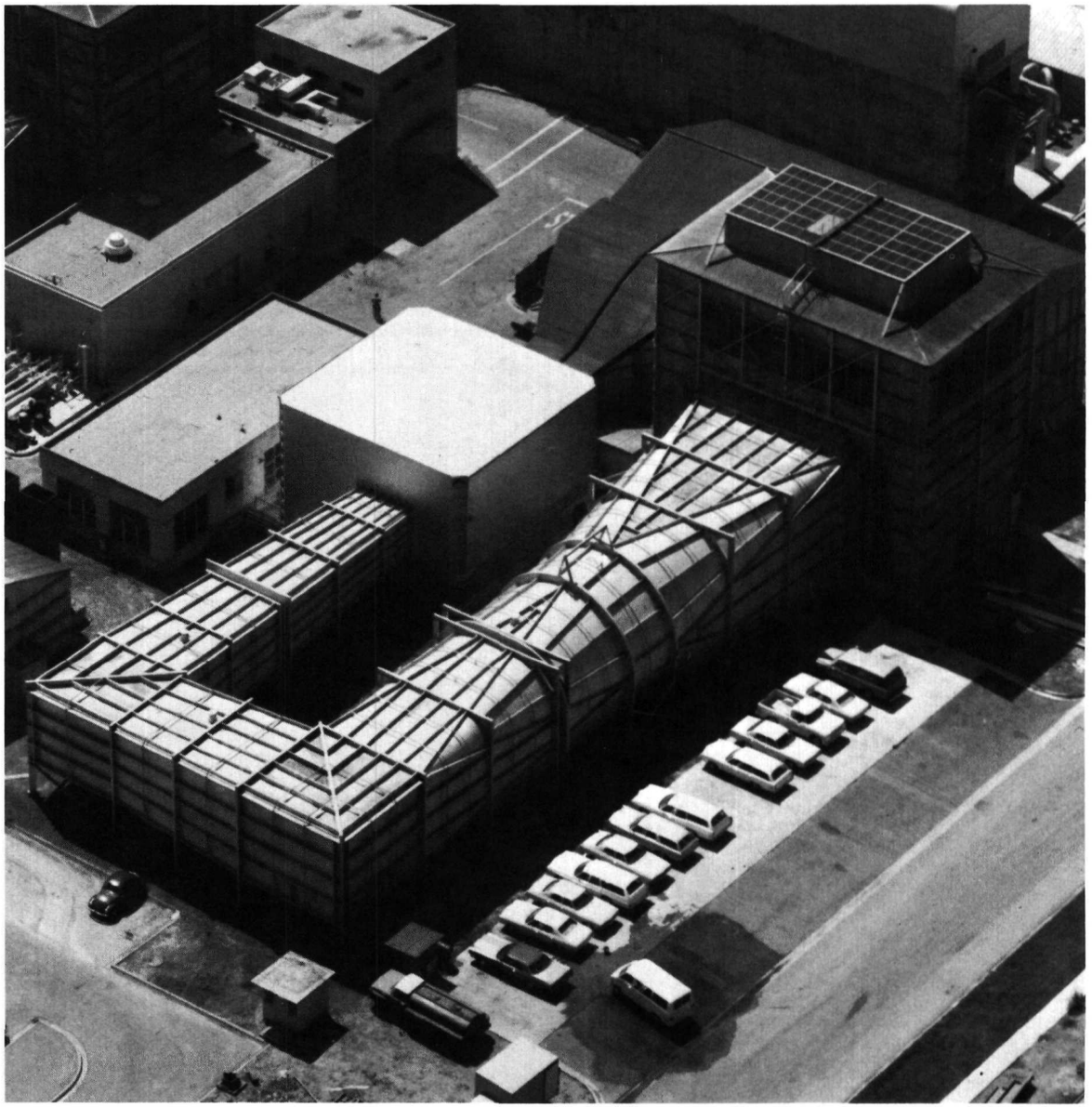
Operational since 1941

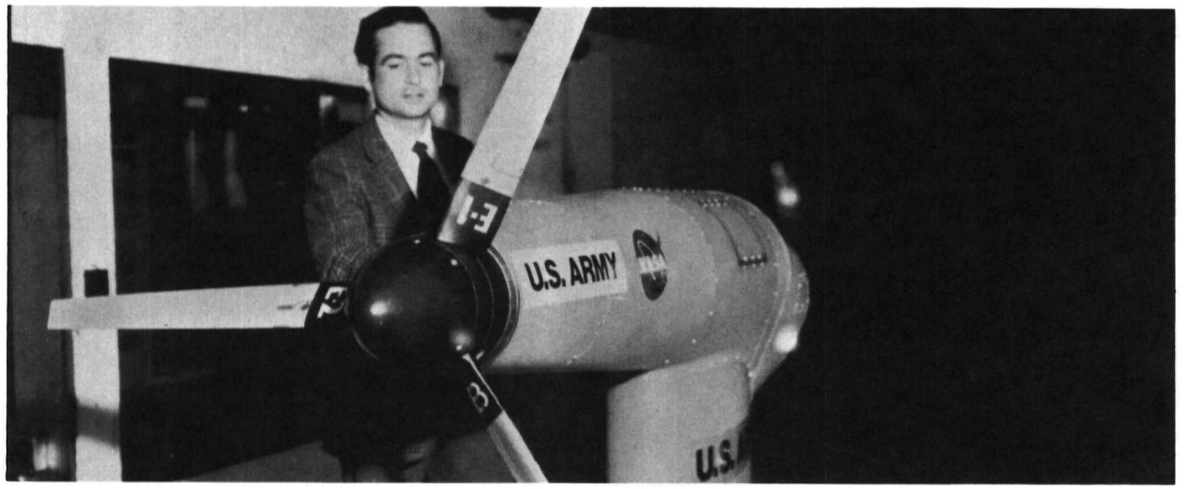
JURISDICTION:

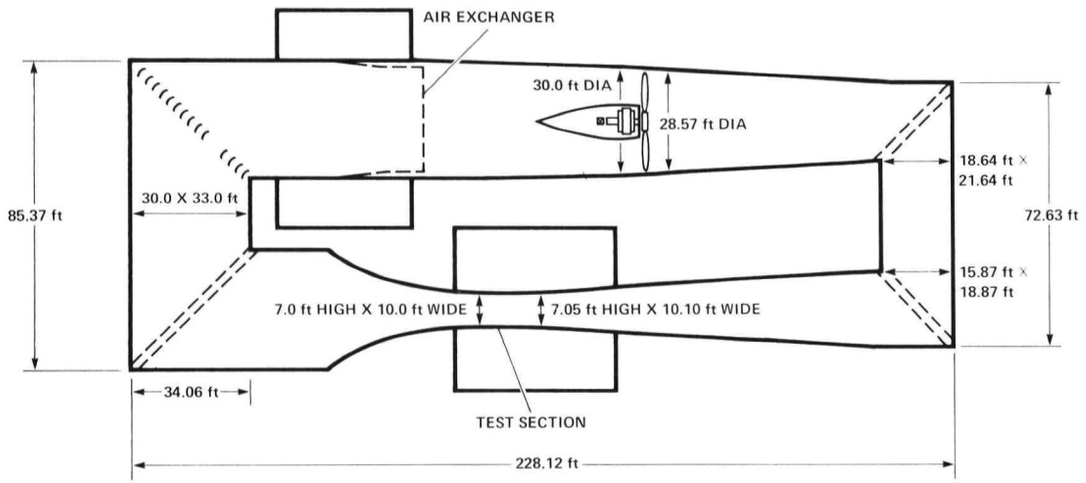
U.S. Army Air Mobility R & D Laboratory
Ames Directorate
Director: Dr. Irving C. Statler

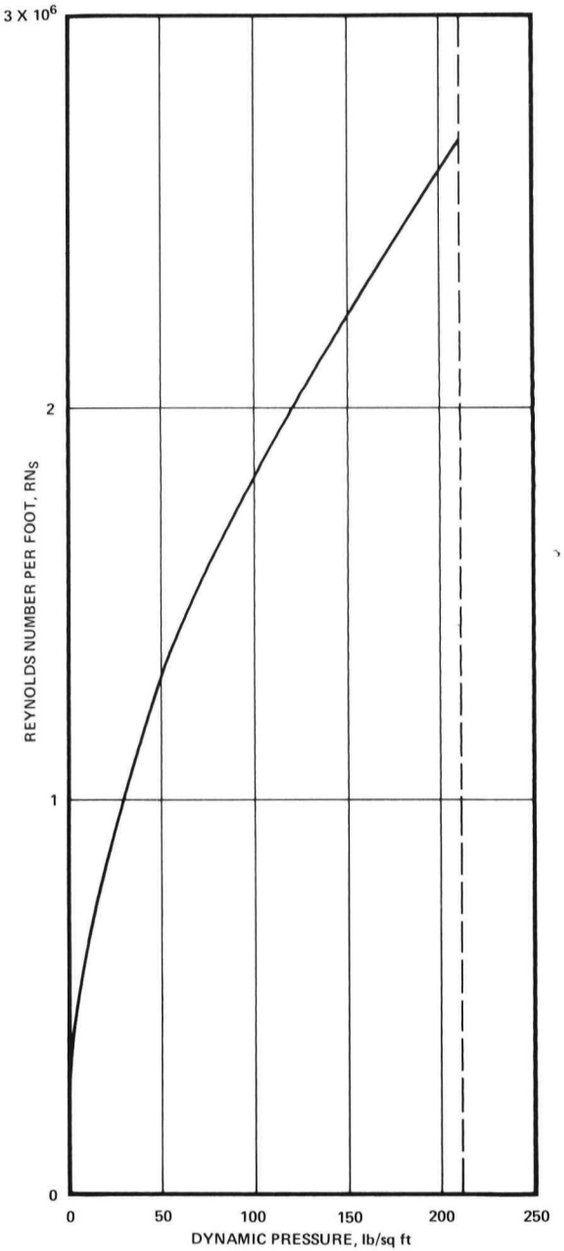
LOCATION:

Building N-216




U.S. ARMY


AIR EXCHANGER
30.0 ft DIA
28.57 ft DIA
18.64 ft X
21.64 ft
72.63 ft
85.37 ft
30.0 X 33.0 ft
15.87 ft X
18.87 ft
7.0 ft HIGH X 10.0 ft WIDE
7.05 ft HIGH X 10.10 ft WIDE
34.06 ft
TEST SECTION
228.12 ft


3 X 10^6
2
1
0
REYNOLDS NUMBER PER FOOT, RNs
0
50
100
150
200
250
DYNAMIC PRESSURE, lb/sq ft

3. TWELVE-FOOT PRESSURE WIND TUNNEL

DESCRIPTION:

The Twelve-Foot Pressure Wind Tunnel is a variable-density, low-turbulence tunnel that operates at subsonic speeds up to slightly less than Mach number 1.0. Airflow is produced by a two-stage, axial-flow variable-speed fan powered by electric motors delivering a total of 12,000 horsepower. Eight fine-mesh screens in the settling chamber, together with the contraction ratio of 25 to 1, provide an airstream of exceptionally low turbulence.

A variety of tests can be accomplished using various model-support systems available. These include sting, semi-span and two-dimensional-model type mountings. (A special mounting drive system is available for high angle of attack.) External and internal strain-gage balances are available.

Motion pictures of models can be taken by remotely operated cameras mounted in the balance chamber.

PERFORMANCE:

Mach Number	0. to 0.98 (continuously variable)
Stagnation Pressure	0.17 to 5.0 atmospheres
Reynolds Number	0 to 9.0×10^6 per foot
Stagnation Temperature	500 to 625° R

DIMENSIONS: Test Section

Height	11.3 feet
Width	11.3 feet
Length	18.0 feet
Access	Top hatch – 5.0 X 11.0 feet

STATUS:

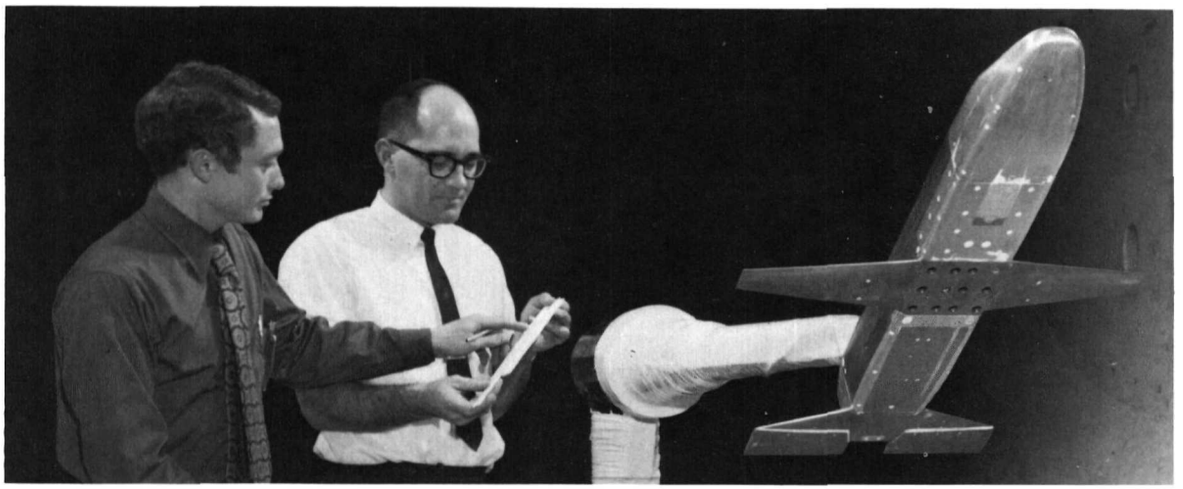
Operational since 1946

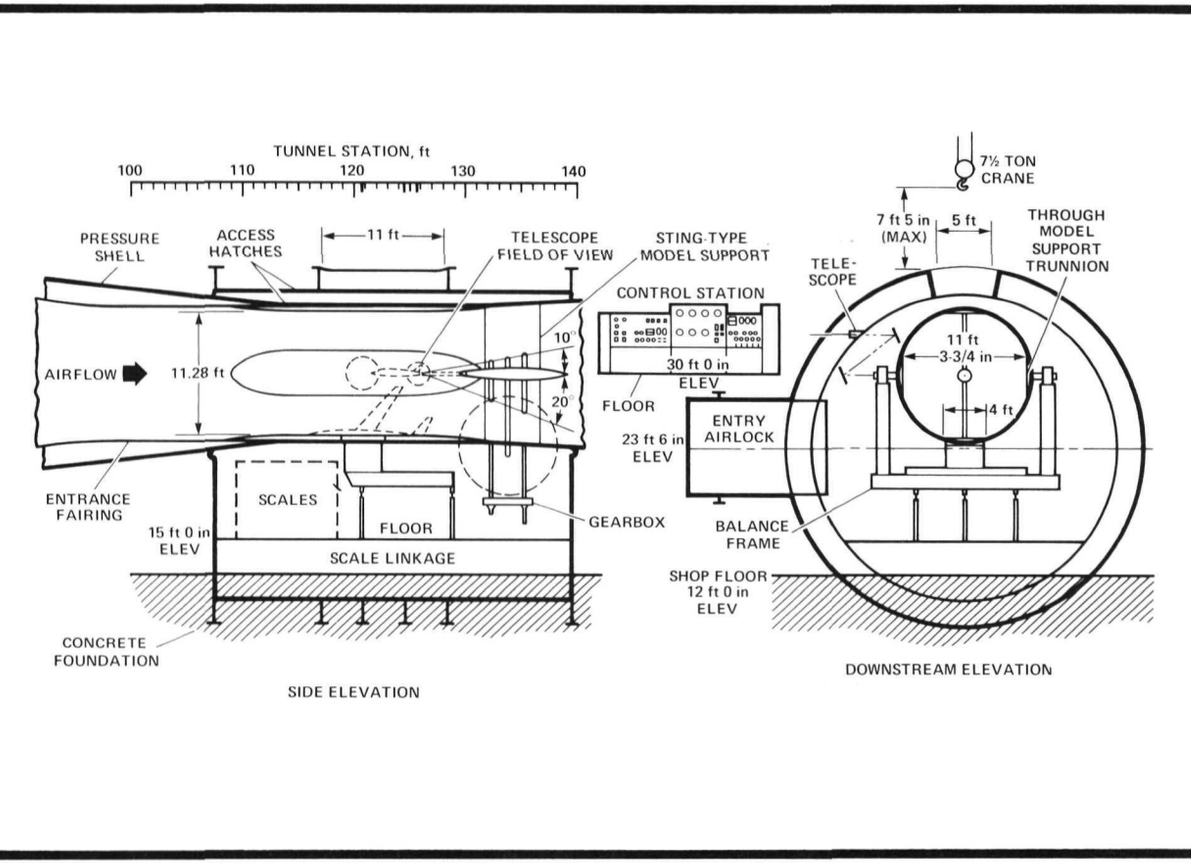
JURISDICTION:

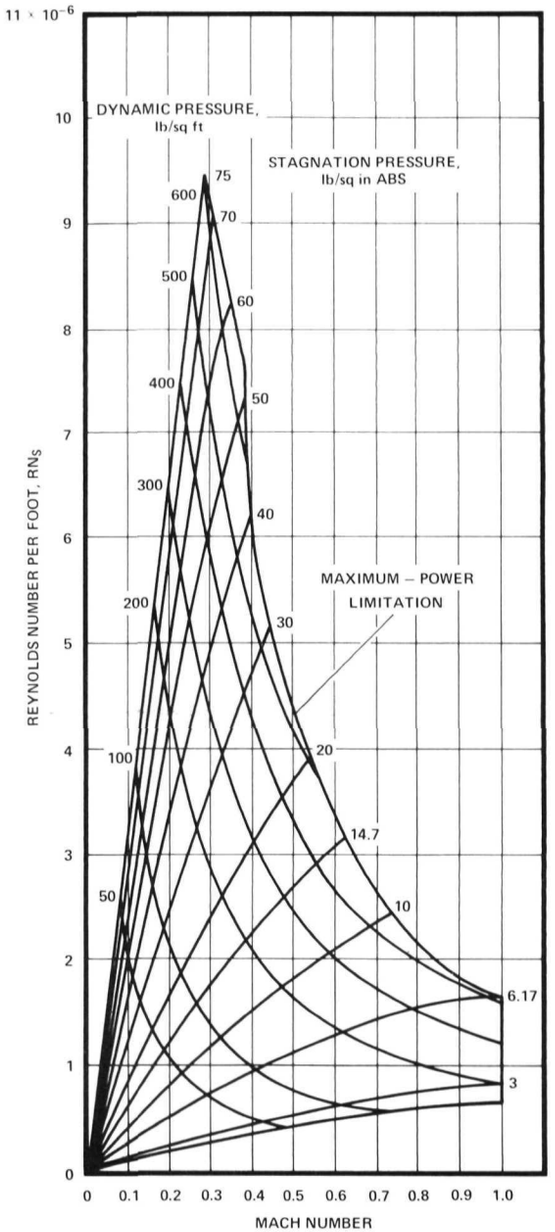
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

LOCATION:

Building N-206




TUNNEL STATION, ft
100
110
120
130
140
PRESSURE SHELL
ACCESS HATCHES
11 ft
TELESCOPE FIELD OF VIEW
STING-TYPE MODEL SUPPORT
CONTROL STATION
AIRFLOW
11.28 ft
10°
20°
30 ft 0 in ELEV
FLOOR
ENTRANCE FAIRING
SCALES
FLOOR
15 ft 0 in ELEV
SCALE LINKAGE
GEARBOX
CONCRETE FOUNDATION
SIDE ELEVATION
7½ TON CRANE
7 ft 5 in (MAX)
5 ft
THROUGH MODEL SUPPORT TRUNNION
TELE-SCOPE
11 ft 3-3/4 in
4 ft
ENTRY AIRLOCK
23 ft 6 in ELEV
BALANCE FRAME
SHOP FLOOR 12 ft 0 in ELEV
DOWNSTREAM ELEVATION


11 × 10⁻⁶
DYNAMIC PRESSURE, lb/sq ft
STAGNATION PRESSURE, lb/sq in ABS
REYNOLDS NUMBER PER FOOT, RN5
MAXIMUM – POWER LIMITATION
MACH NUMBER
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1
2
3
4
5
6
7
8
9
10
600
500
400
300
200
100
50
75
70
60
50
40
30
20
14.7
10
6.17
3

4. FOURTEEN-FOOT TRANSONIC WIND TUNNEL

DESCRIPTION:

The Fourteen-Foot Transonic Wind Tunnel is a closed-circuit tunnel equipped with an adjustable, flexible-wall nozzle and a test section with four slotted walls. (The air circuit is closed except for the air exchanger, in a low-speed section, which is controlled to maintain suitable air temperature.) Airflow is produced by a three-stage, axial-flow compressor powered by three variable-speed, electric motors mounted in tandem outside the tunnel, rated at 110,000 horsepower continuously or 132,000 hp for one hour.

For conventional, steady-state testing models are generally supported on an adjustable sting. Internal, strain-gage balances are used for measuring forces and moments. Additional facilities are available for measuring multiple steady or fluctuating pressures, as well as variable-speed compact model motors with a variable-frequency power source.

A schlieren system is available for flow visualization.

PERFORMANCE:

Mach Number	0.6 to 1.2 (continuously variable)
Stagnation Pressure	1.0 atmosphere
Reynolds Number	2.8×10^6 to 4.2×10^6 per foot
Stagnation Temperature	Generally 640° R

DIMENSIONS: Test Section

Height	13.5 feet
Width	13.71 feet (upstream)
	13.92 feet (downstream)
Length	33.75 feet
Access	Side doors – 6.7 X 8.0 feet

STATUS:

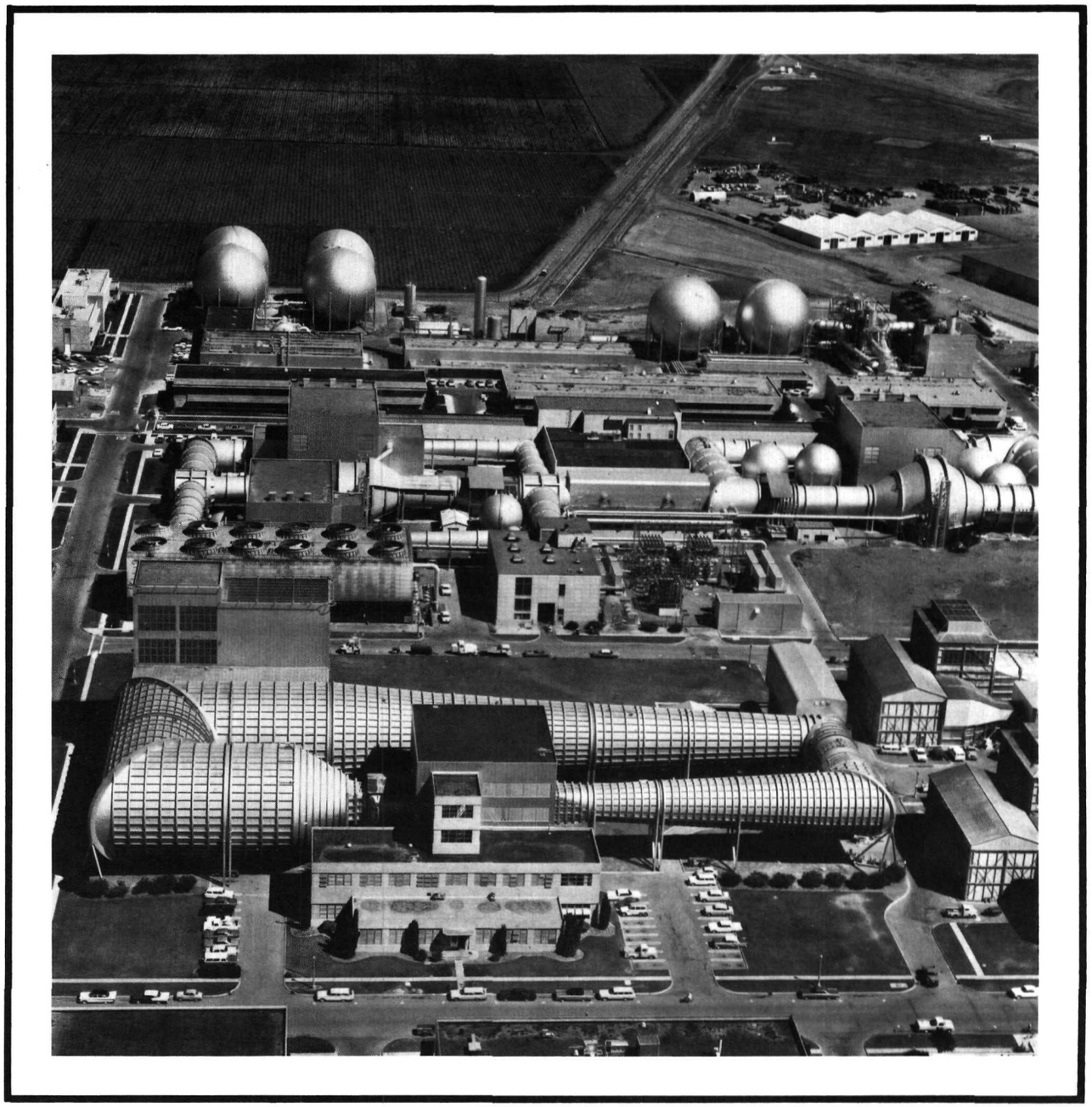
Operational since 1956

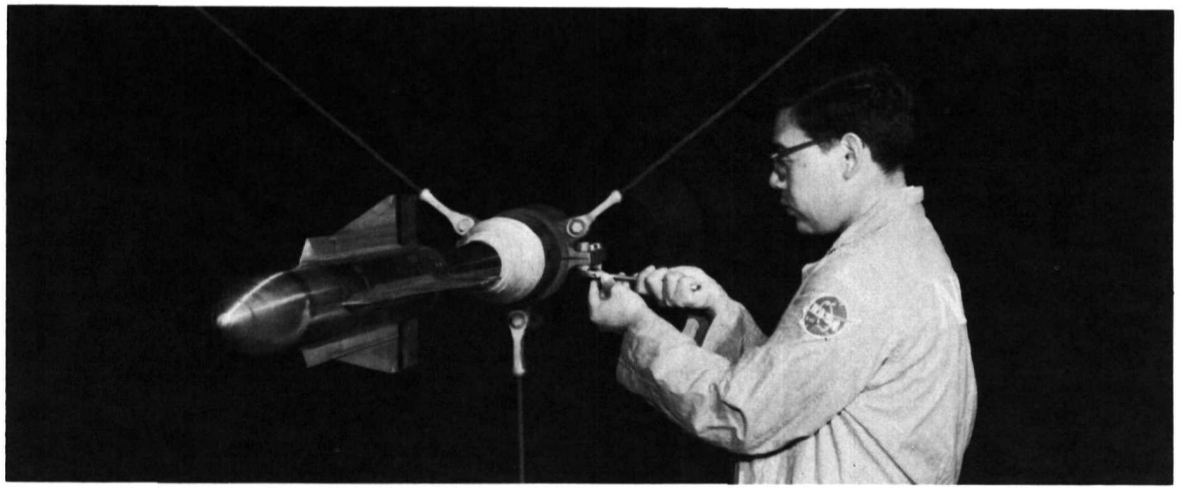
JURISDICTION:

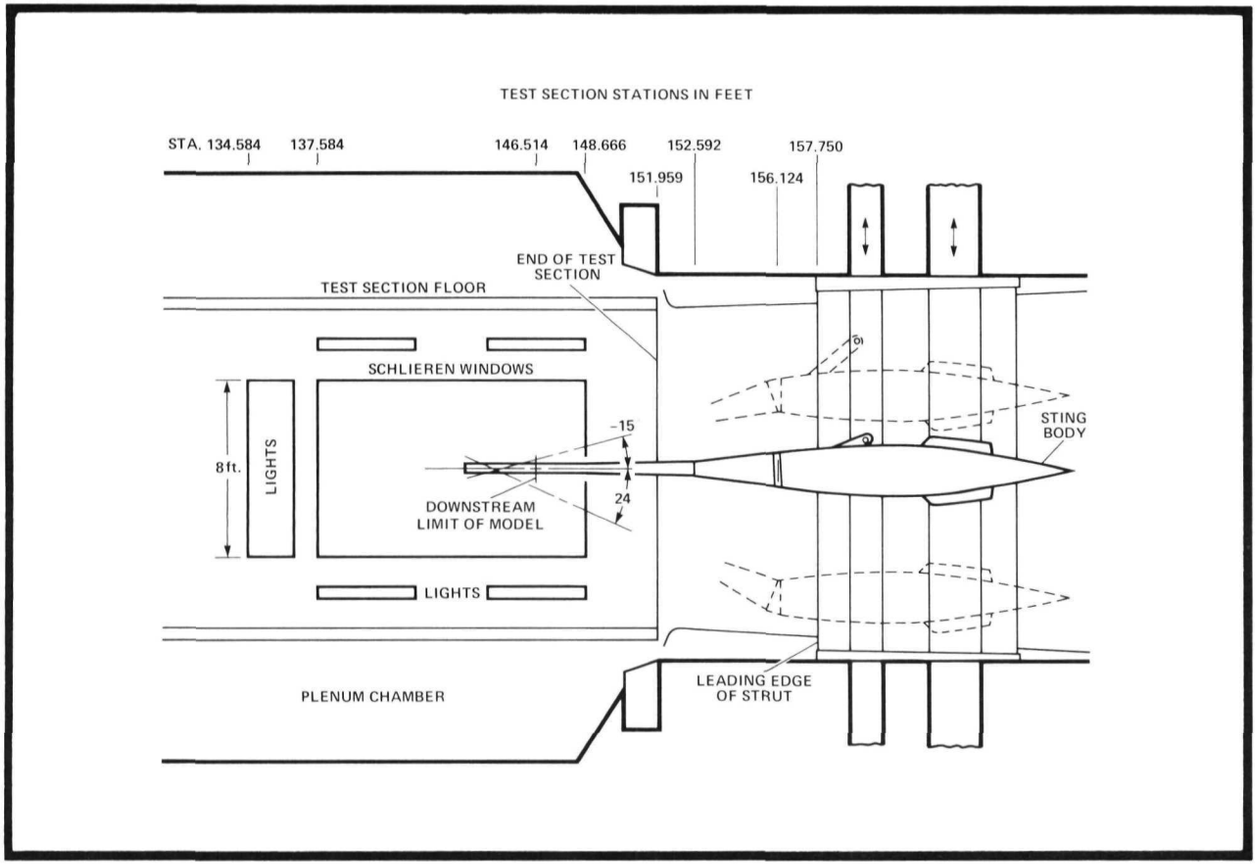
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

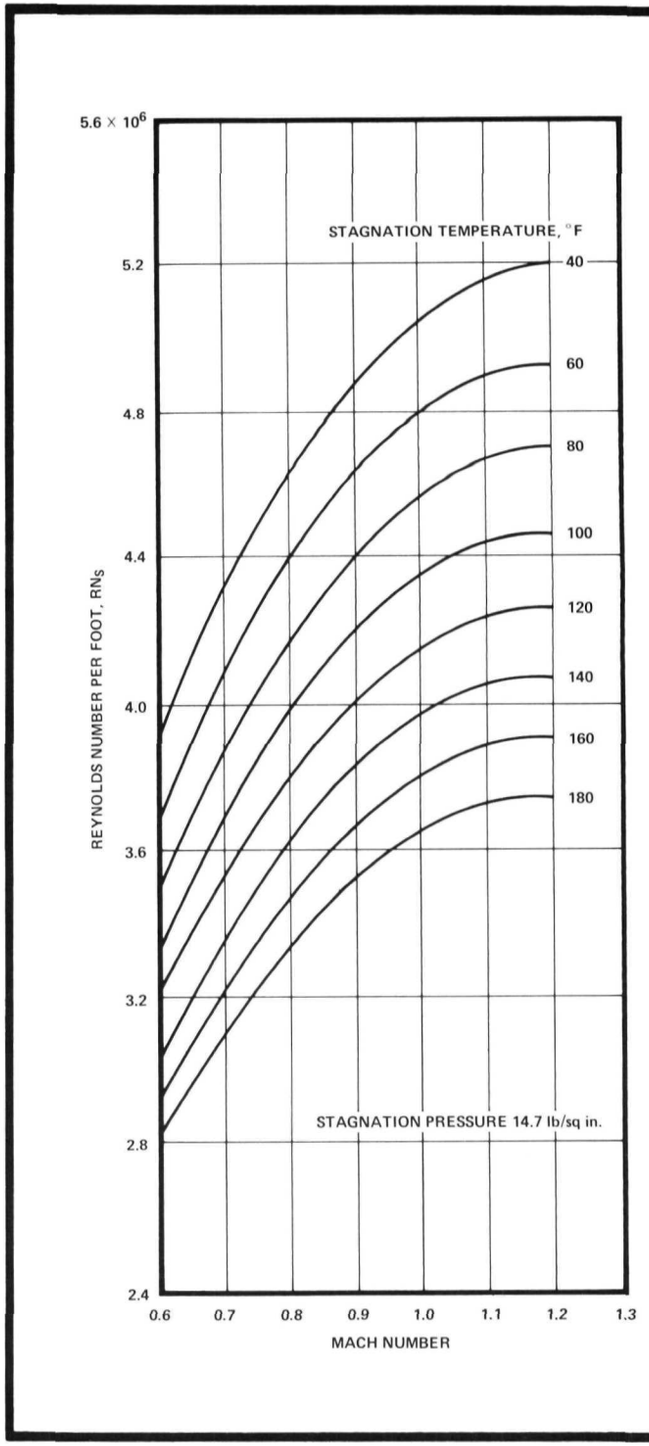
LOCATION:

Building N-218






TEST SECTION STATIONS IN FEET
STA. 134.584
137.584
146.514
148.666
151.959
152.592
156.124
157.750
END OF TEST SECTION
TEST SECTION FLOOR
SCHLIEREN WINDOWS
8 ft.
LIGHTS
-15
24
DOWNSTREAM LIMIT OF MODEL
STING BODY
LIGHTS
PLENUM CHAMBER
LEADING EDGE OF STRUT


5.6 × 10^6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
REYNOLDS NUMBER PER FOOT, RNs
STAGNATION TEMPERATURE, °F
40
60
80
100
120
140
160
180
STAGNATION PRESSURE 14.7 lb/sq in.
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
MACH NUMBER

5. TWO-BY TWO-FOOT TRANSONIC WIND TUNNEL

DESCRIPTION:

The Two- by Two-Foot Transonic Wind Tunnel is a closed-return, variable-density tunnel equipped with an adjustabie, flexible-wall nozzle and a slotted test section. Airflow is produced by a two-stage, axial-flow compressor powered by four, variable-speed induction motors mounted in tandem, delivering a total of 4,000 horsepower. For conventional, steady-state testing models are generally supported on a sting. Internal, strain-gage balances are used for measuring forces and moments. (Additional facilities are available for measuring multiple steady or fluctuating pressures.)

This facility is also used for panel-flutter testing (one test-section wall is replaced with another containing the test specimen).

PERFORMANCE:

Mach Number	0.2 to 1.4 (continuously variable)
Stagnation Pressure	0.16 to 3.0 atmospheres
Reynolds Number	0.5×10^6 to 8.7×10^6 per foot
Stagnation Temperature	580° R

DIMENSIONS: Test Section

Height	2.0 feet
Width	2.0 feet
Length	5.0 feet
Access	Side doors — 2.0 × 5.0 feet

STATUS:

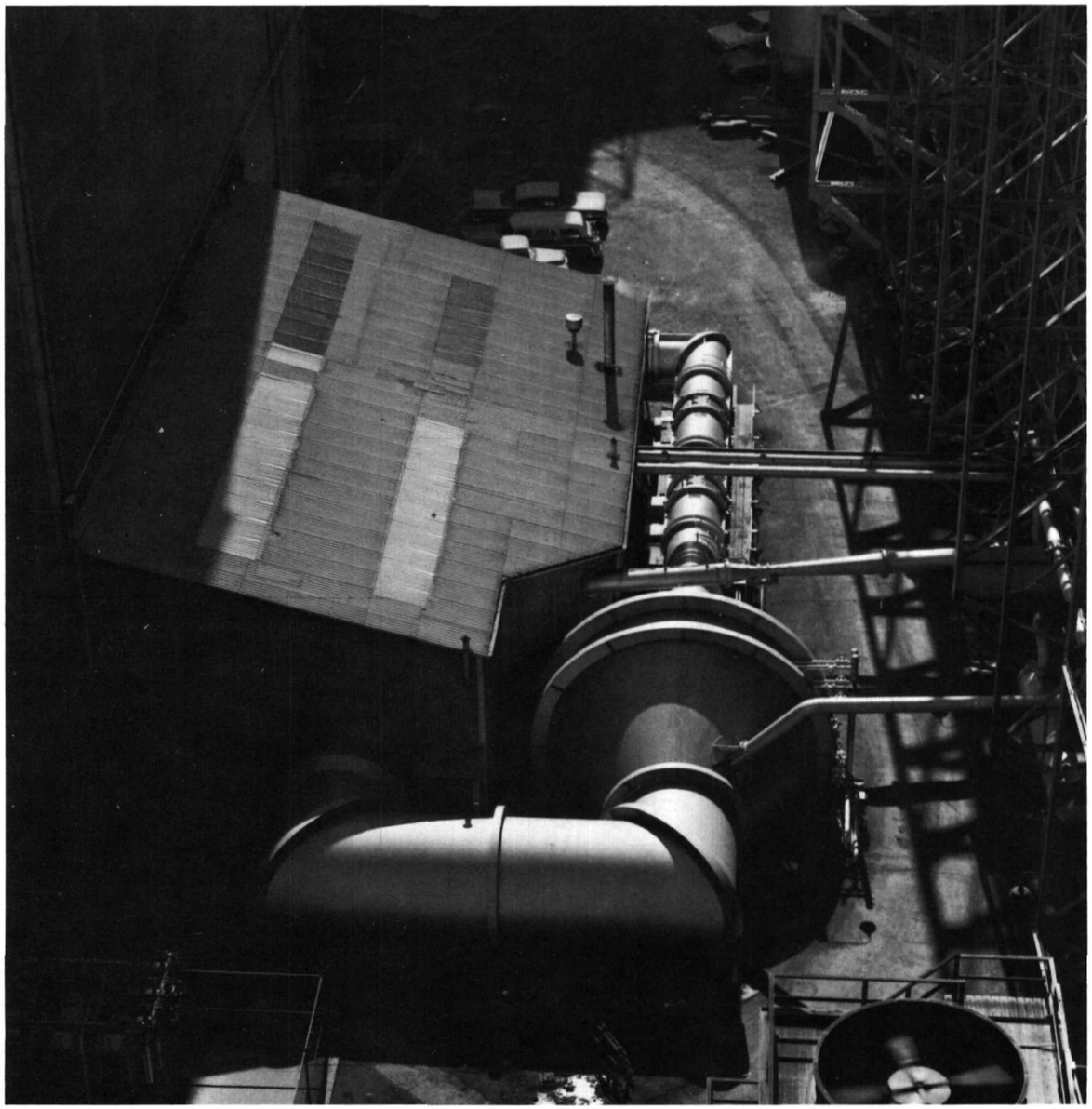
Operational since 1951

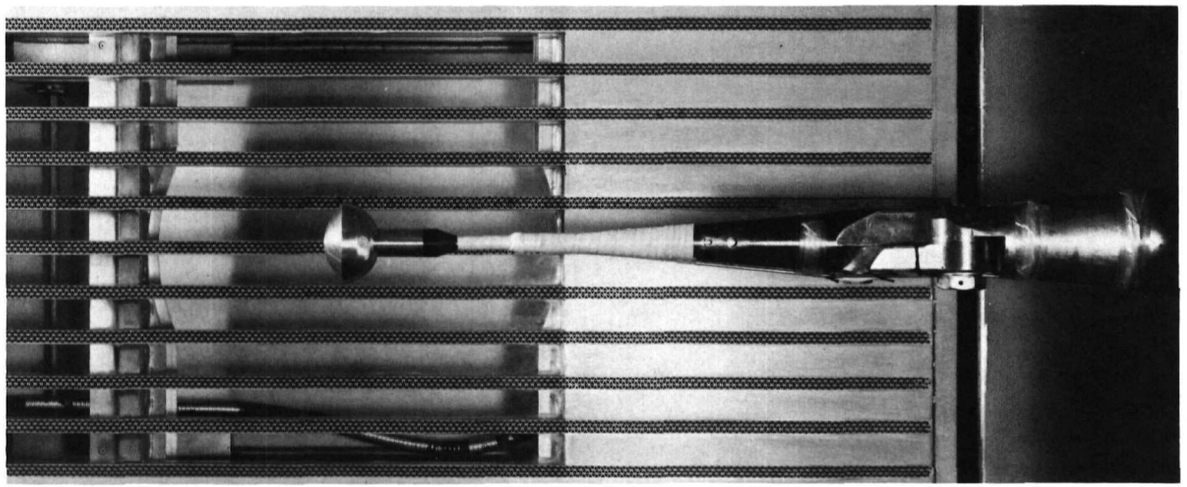
JURISDICTION:

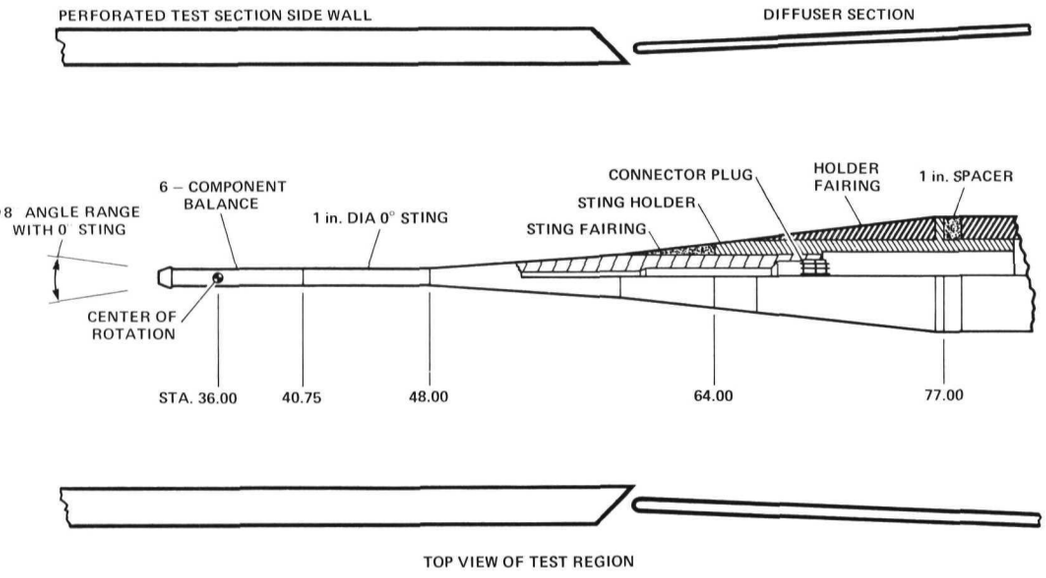
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

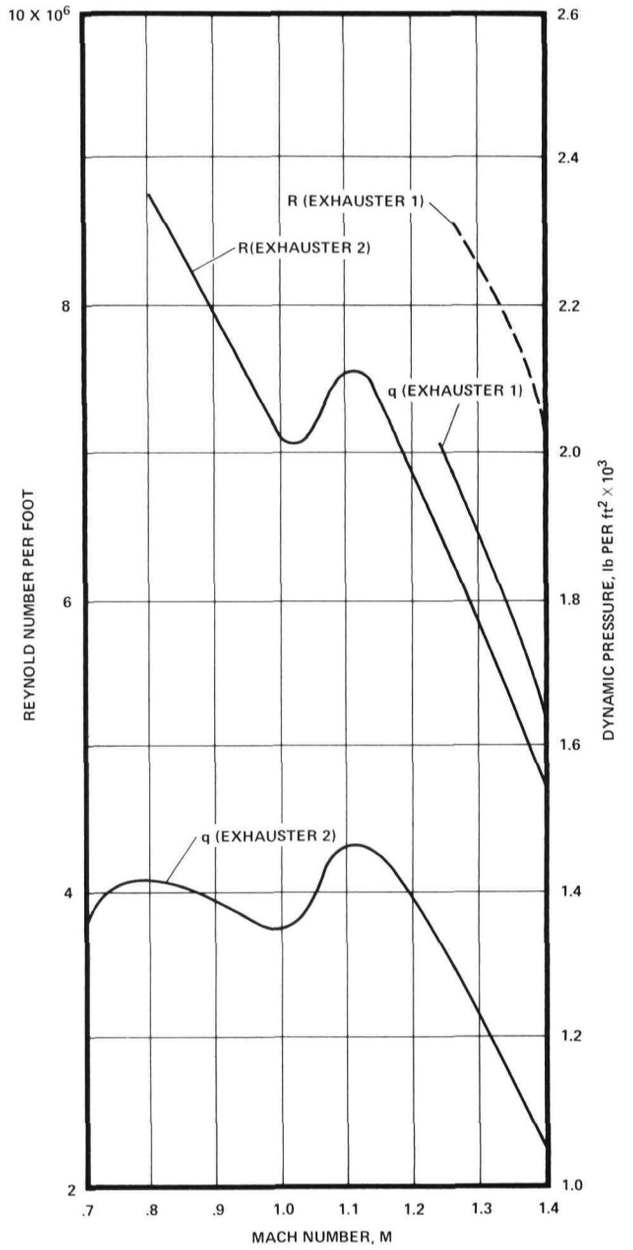
LOCATION:

Building N-222

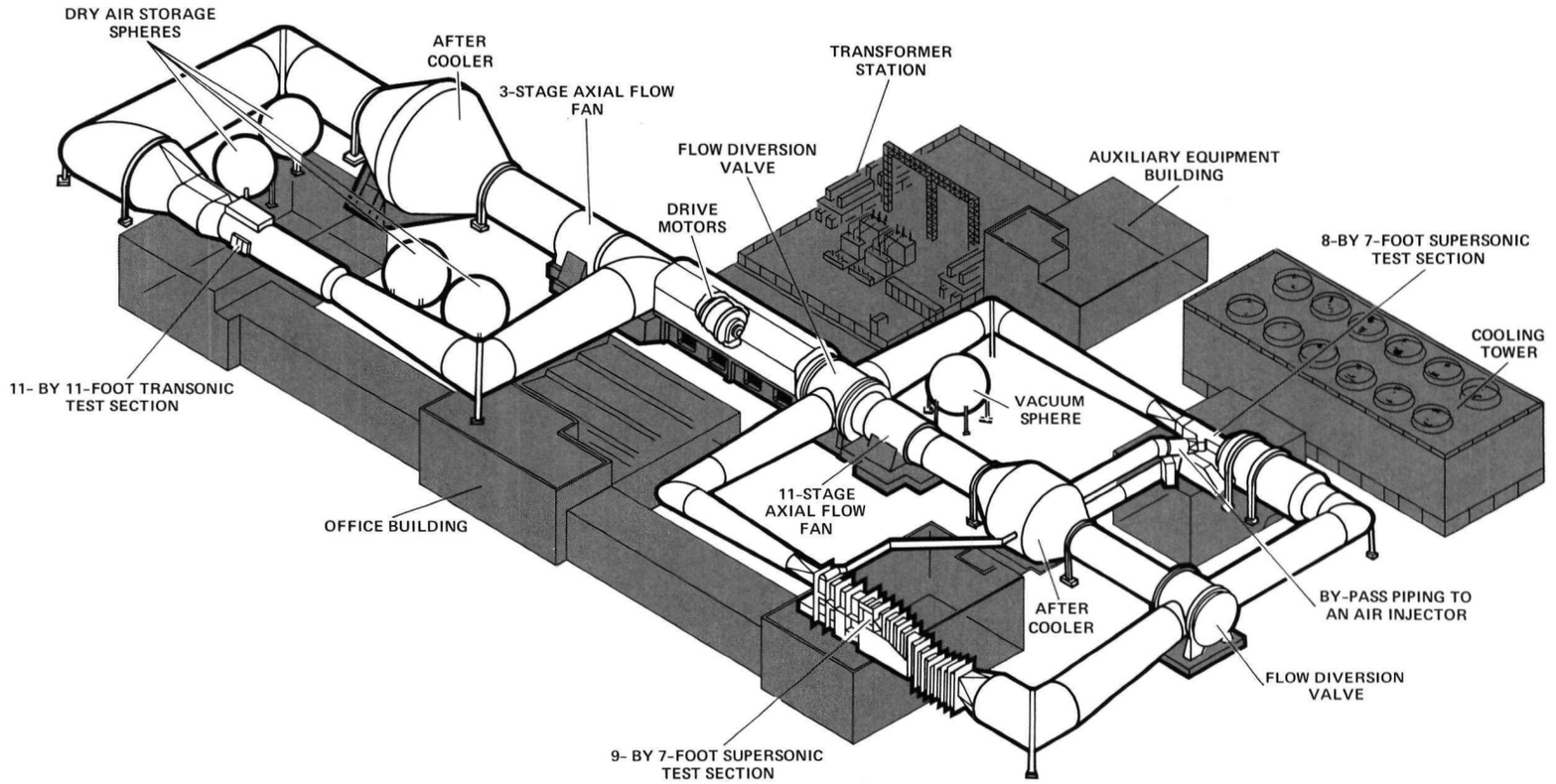





PERFORATED TEST SECTION SIDE WALL
DIFFUSER SECTION
±8 ANGLE RANGE WITH 0° STING
6 – COMPONENT BALANCE
1 in. DIA 0° STING
CONNECTOR PLUG
STING HOLDER
STING FAIRING
HOLDER FAIRING
1 in. SPACER
CENTER OF ROTATION
STA. 36.00
40.75
48.00
64.00
77.00
TOP VIEW OF TEST REGION

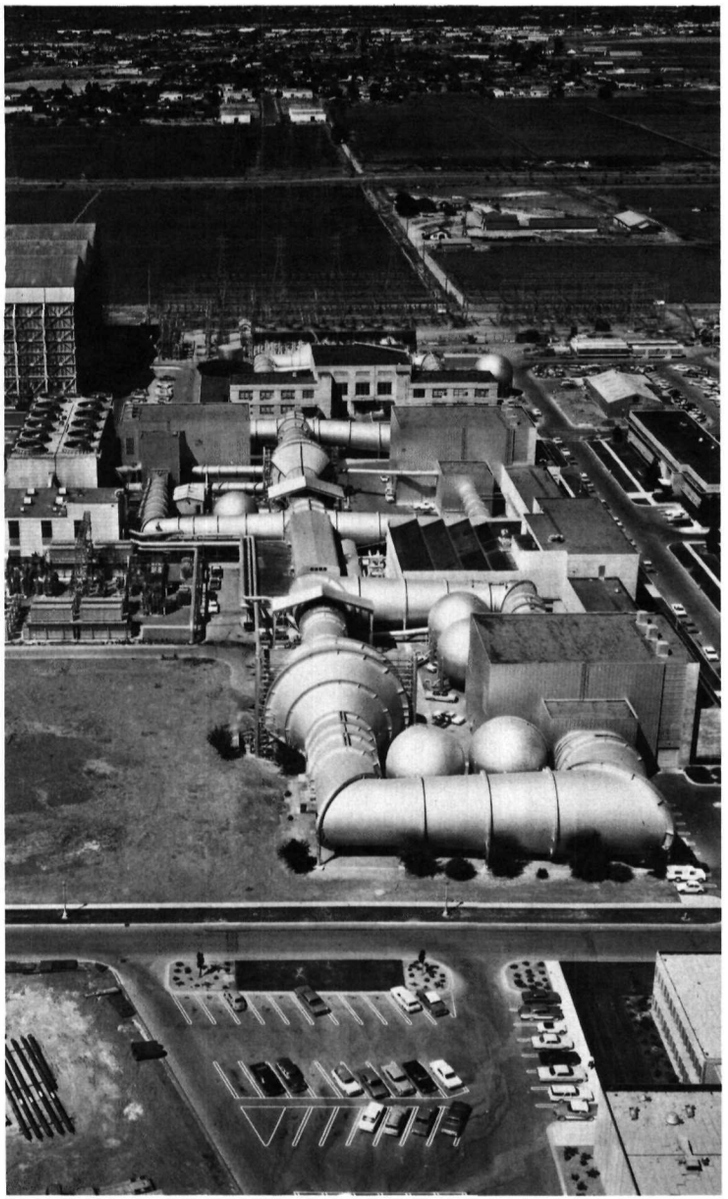

10 X 10^6
REYNOLD NUMBER PER FOOT
DYNAMIC PRESSURE, lb PER ft² X 10³
R (EXHAUSTER 1)
R(EXHAUSTER 2)
q (EXHAUSTER 1)
q (EXHAUSTER 2)
MACH NUMBER, M
2
4
6
8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4

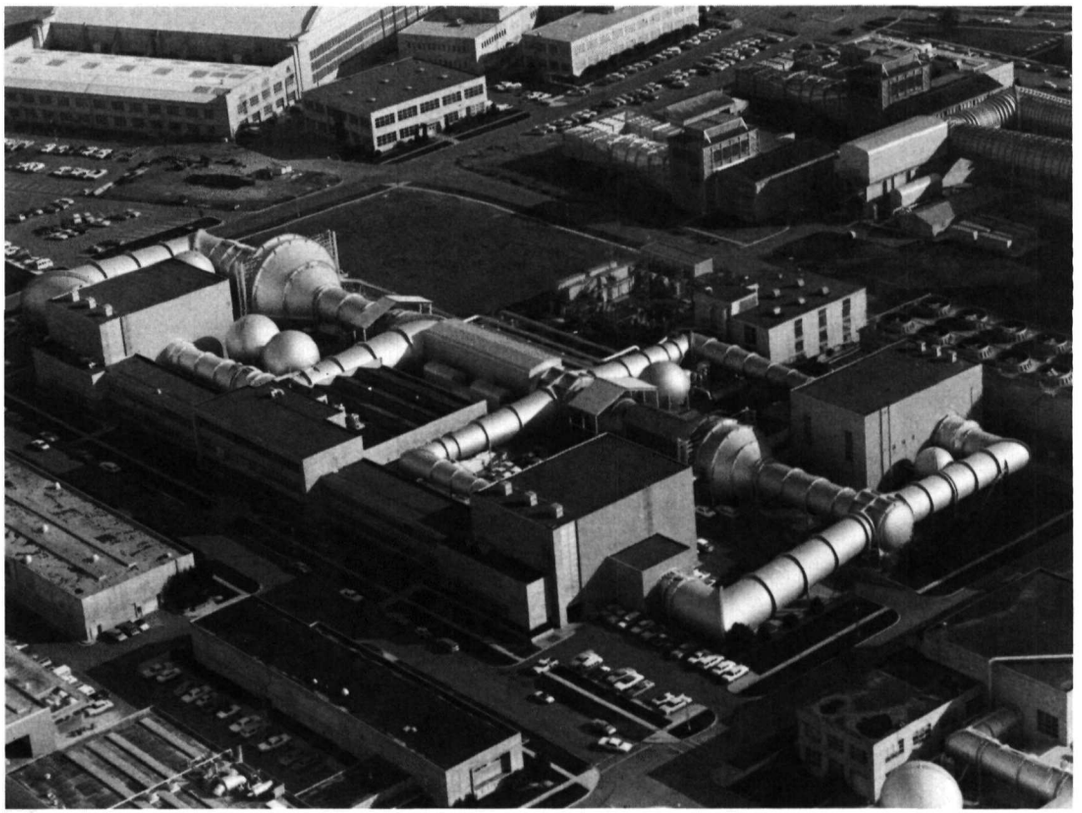
6. UNITARY PLAN WIND TUNNELS



MAJOR COMPONENTS OF THE UNITARY PLAN WIND TUNNELS

Unitary Test Sections	Height and Width, ft	Speed Range	Stagnation Press, atm	Stagnation Temp, °R	Reynolds No./ft	Dynamic Pressure, lb/ft^2	Special Features
Eleven Foot Transonic	Eleven by Eleven	0.70 to 1.4 M	0.5 to 2.25	580	1.7 to 9.4 $\times 10^6$	250 to 2000	Slotted Test Section, 4 Walls
Nine-by Seven-Foot Supersonic	Seven by Nine	1.55 to 2.5 M	0.3 to 2.0	580	1.5 to 6.5 $\times 10^6$	200 to 1450	
Eight-by Seven-Foot Supersonic	Eight by Seven	2.45 to 3.5 M	0.3 to 2.0	580	1.0 to 5.0 $\times 10^6$	200 to 1000	





Unitary Plan Wind Tunnels

The Ames Unitary Plan facility is a unique system of wind tunnels comprised of three test sections: an Eleven-by Eleven-Foot Transonic Tunnel (Mach 0.40 to 1.40), a Nine-by Seven-Foot Supersonic Tunnel (Mach 1.55 to 2.50), and an Eight-by Seven-Foot Supersonic Tunnel (Mach 2.45 to 3.45), all capable of operating at variable stagnation pressures.

The major common element of the tunnel complex is its electric powerplant consisting of four intercoupled motors capable of generating a total of 180,000 horsepower continuously. Construction of this facility began in 1951 and was fully operational by 1955. This facility is considered a landmark in the development of supersonic wind tunnels.

6a. ELEVEN-BY ELEVEN-FOOT WIND TUNNEL

DESCRIPTION:

The Eleven-by Eleven-Foot Transonic Wind Tunnel is a closed-return, variable density tunnel with a fixed geometry, ventilated throat and a single-jack flexible nozzle. Airflow is produced by a three-stage, axial-flow compressor powered by four wound-rotor variable-speed induction motors.

For conventional steady-state testing models are generally supported on a sting. Internal strain-gage balances are used for measuring forces and moments. (Additional facilities are available for measuring multiple steady or fluctuating pressures.)

A schlieren system is available for studying flow patterns by direct viewing or photography, as well as a system for obtaining 20-by 40-inch shadowgraph negatives.

PERFORMANCE:

Mach Number	0.4 to 1.4 (continuously variable)
Stagnation Pressure	0.5 to 2.25 atmospheres
Reynolds Number	1.7×10^6 to 9.4×10^6 per foot
Stagnation Temperature	580° R

DIMENSIONS: Test Section

Height	11.0 feet
Width	11.0 feet
Length	22.0 feet
Access	Top hatch — 7.0 X 22.0 feet

STATUS:

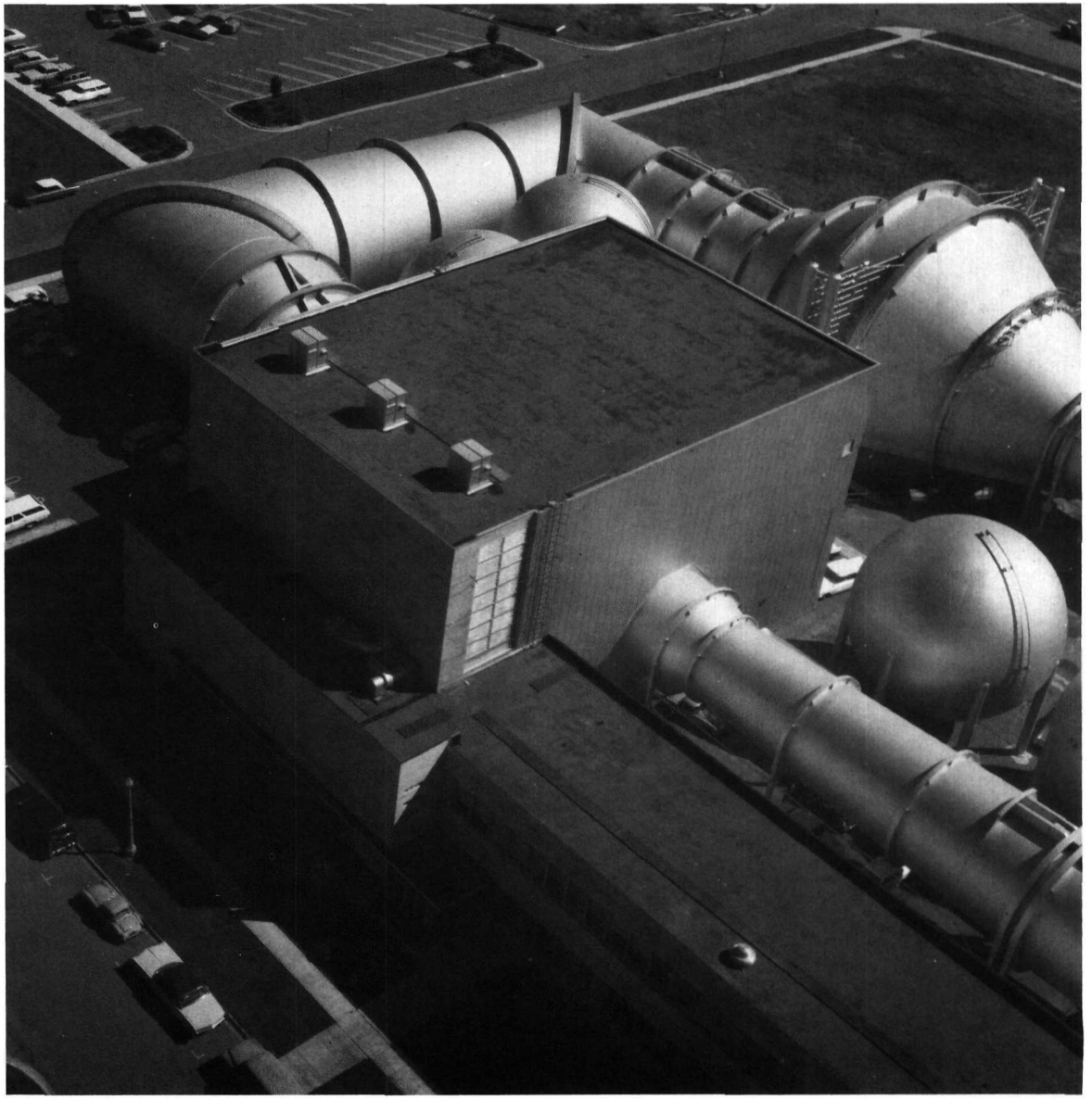
Operational since 1956

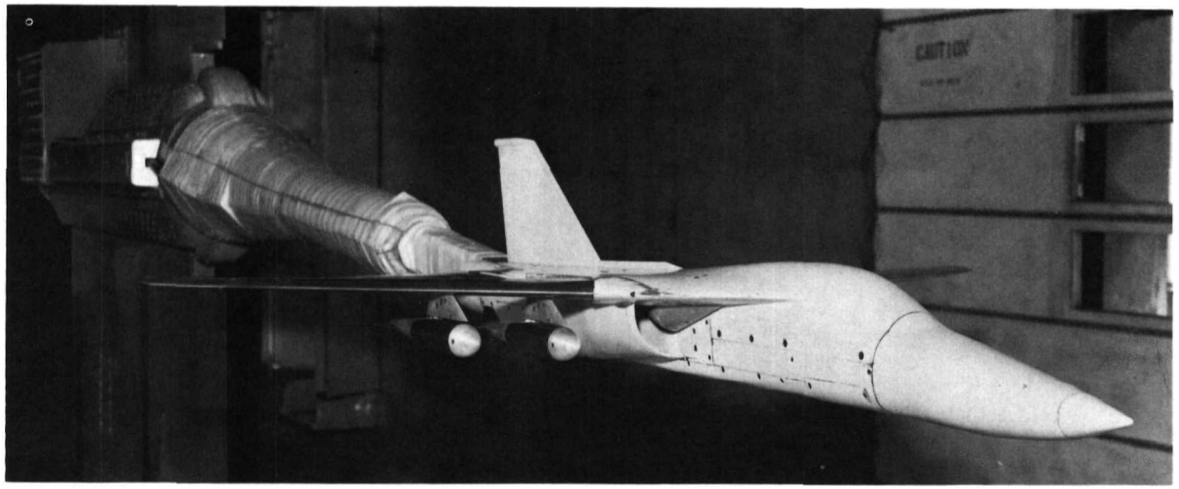
JURISDICTION:

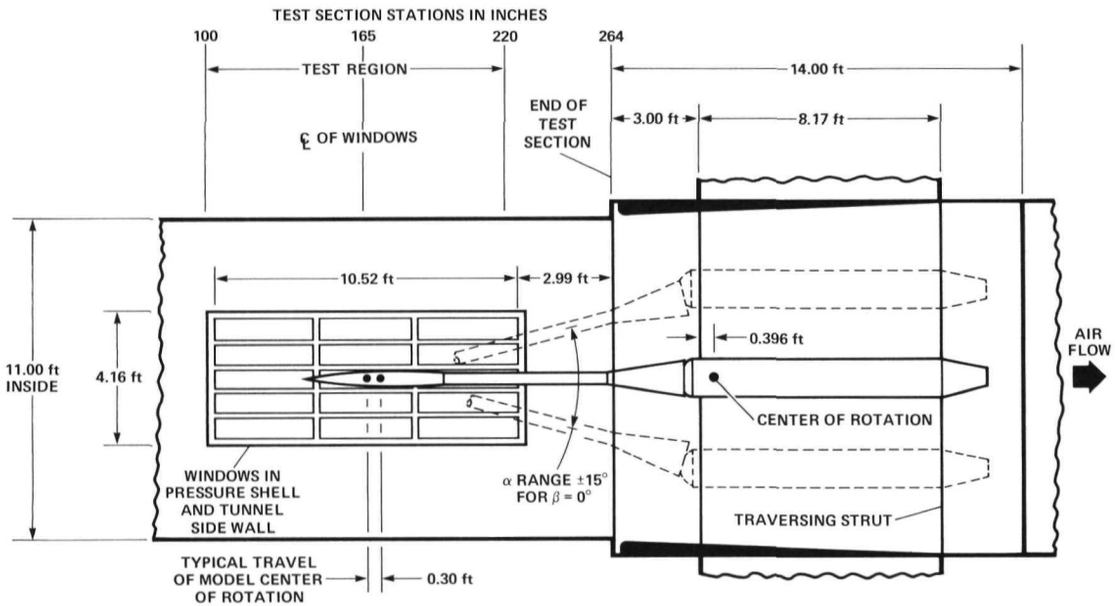
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

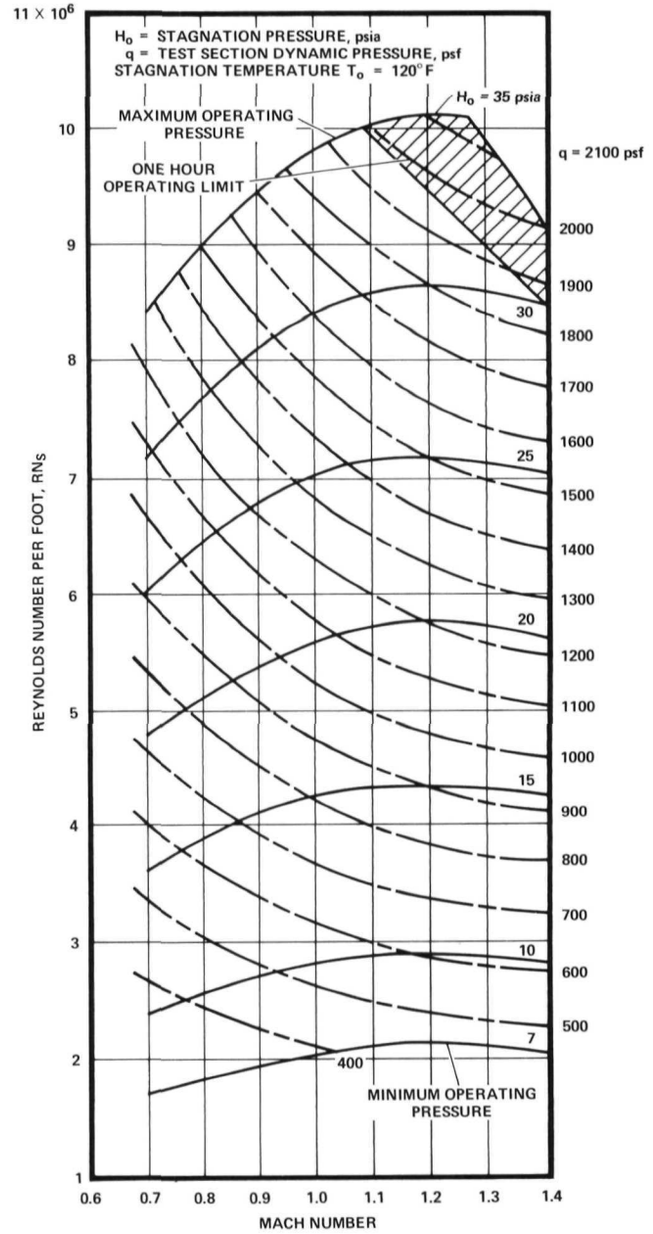
LOCATION:

Building N-227A






TEST SECTION STATIONS IN INCHES
100
165
220
264
TEST REGION
14.00 ft
℄ OF WINDOWS
END OF TEST SECTION
3.00 ft
8.17 ft
10.52 ft
2.99 ft
0.396 ft
11.00 ft INSIDE
4.16 ft
AIR FLOW
CENTER OF ROTATION
WINDOWS IN PRESSURE SHELL AND TUNNEL SIDE WALL
α RANGE ±15° FOR β = 0°
TRAVERSING STRUT
TYPICAL TRAVEL OF MODEL CENTER OF ROTATION
0.30 ft


11 X 10^6
H_o = STAGNATION PRESSURE, psia
q = TEST SECTION DYNAMIC PRESSURE, psf
STAGNATION TEMPERATURE T_o = 120° F
H_o = 35 psia
MAXIMUM OPERATING PRESSURE
ONE HOUR OPERATING LIMIT
q = 2100 psf
REYNOLDS NUMBER PER FOOT, RN_S
MACH NUMBER
MINIMUM OPERATING PRESSURE
30
25
20
15
10
7
400

6b. NINE-BY SEVEN-FOOT SUPERSONIC WIND TUNNEL

DESCRIPTION:

The Nine- by Seven-Foot Supersonic Wind Tunnel is a closed-return, variable density tunnel equipped with an asymmetric, sliding-block nozzle and a flexible upper plate. Variation of the test section Mach number is achieved by translating, in the streamwise direction, the fixed contour block that forms the floor of the nozzle. Airflow is produced by an eleven-stage, axial-flow compressor powered by four variable-speed, wound-rotor induction motors.

For conventional, steady-state testing models are generally supported on a sting. Internal strain-gage balances are used for measuring forces and moments. (Additional facilities are available for measuring multiple steady or fluctuating pressures).

A schlieren system is available for studying flow patterns by direct viewing or photography, as well as a system for obtaining 20-by-20 inch shadowgraph negatives.

PERFORMANCE:

Mach Number	1.55 to 2.5 (continuously variable)
Stagnation Pressure	0.3 to 2.0 atmospheres
Reynolds Number	1.5×10^6 to 6.5×10^6 per foot
Stagnation Temperature	580° R

DIMENSIONS: Test Section

Height	7.0 feet
Width	9.0 feet
Length	18.0 feet
Access	Top hatch – 6.0 X 9.0 feet
	Side door – 3.0 X 6.5 feet

STATUS:

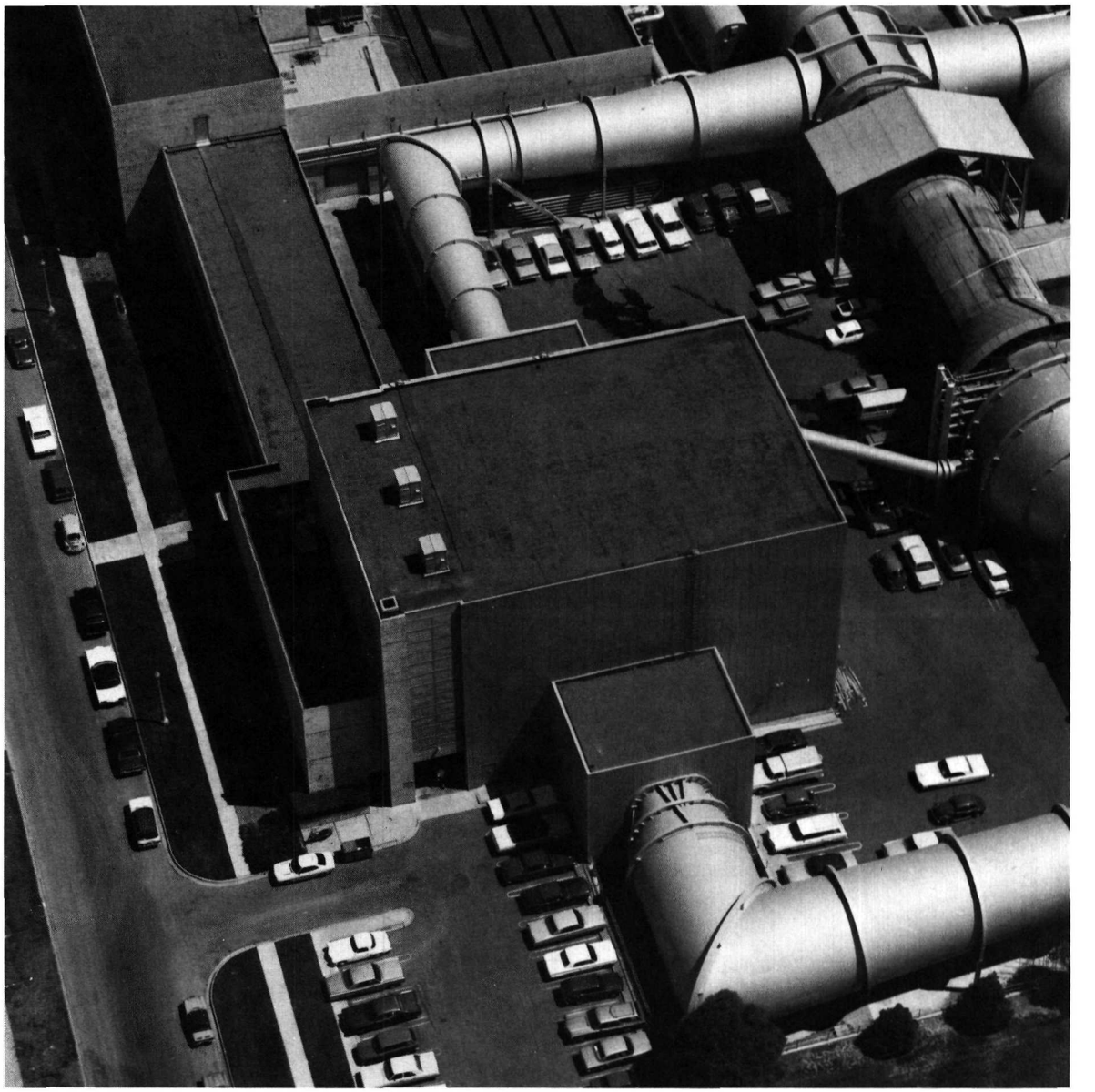
Operational since 1956

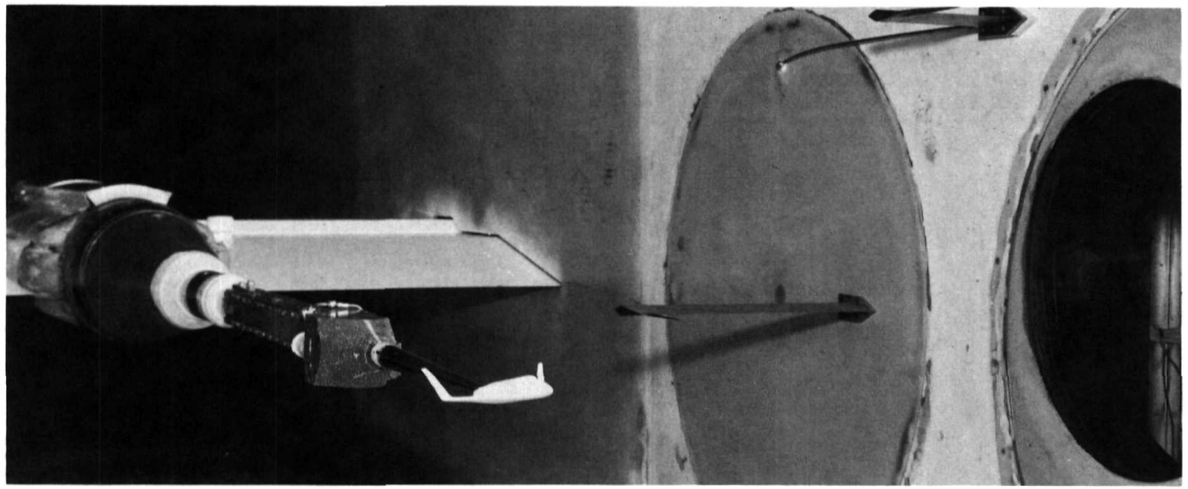
JURISDICTION:

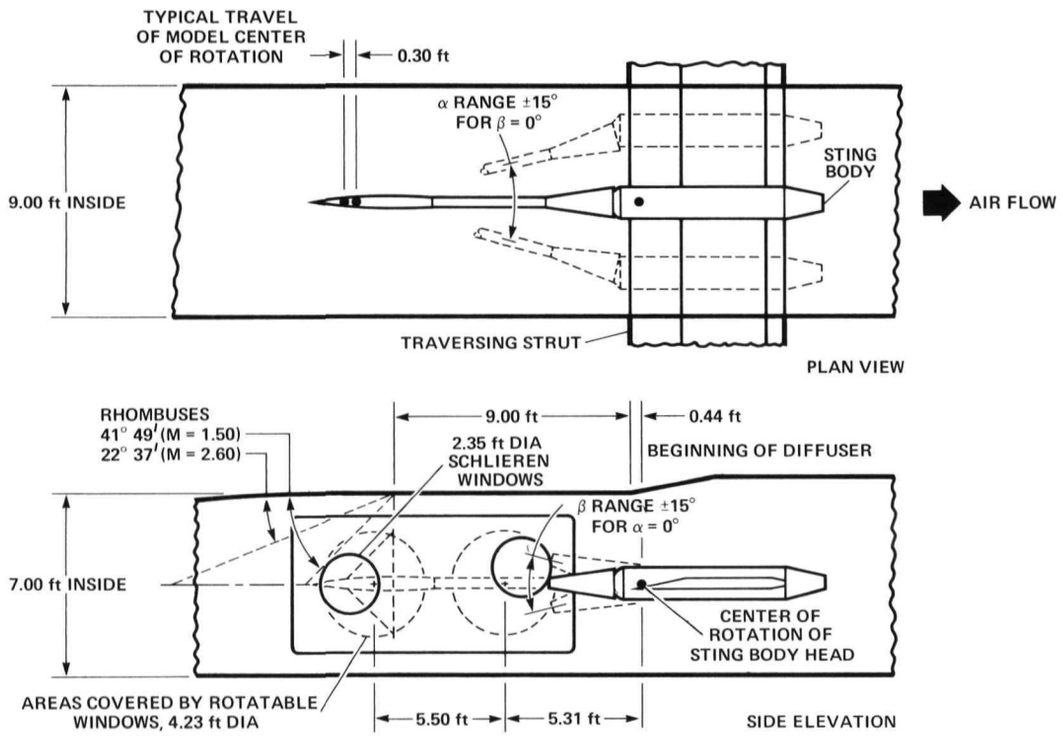
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

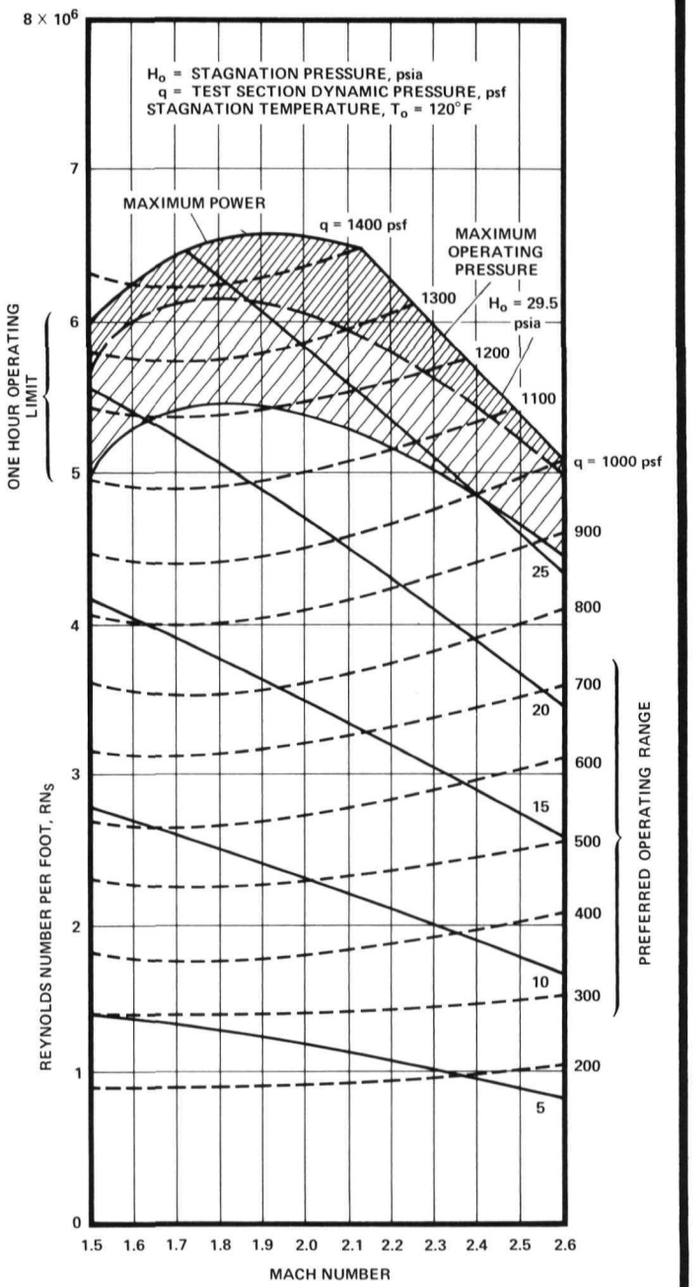
LOCATION:

Building N-227B






TYPICAL TRAVEL
OF MODEL CENTER
OF ROTATION
0.30 ft
α RANGE ±15°
FOR β = 0°
STING
BODY
9.00 ft INSIDE
AIR FLOW
TRAVERSING STRUT
PLAN VIEW
RHOMBUSES
41° 49′ (M = 1.50)
22° 37′ (M = 2.60)
9.00 ft
0.44 ft
2.35 ft DIA
SCHLIEREN
WINDOWS
BEGINNING OF DIFFUSER
β RANGE ±15°
FOR α = 0°
7.00 ft INSIDE
CENTER OF
ROTATION OF
STING BODY HEAD
AREAS COVERED BY ROTATABLE
WINDOWS, 4.23 ft DIA
5.50 ft
5.31 ft
SIDE ELEVATION


8 × 10^6
H_o = STAGNATION PRESSURE, psia
q = TEST SECTION DYNAMIC PRESSURE, psf
STAGNATION TEMPERATURE, T_o = 120° F
MAXIMUM POWER
q = 1400 psf
MAXIMUM
OPERATING
PRESSURE
1300
H_o = 29.5
psia
1200
1100
ONE HOUR OPERATING
LIMIT
q = 1000 psf
900
25
800
700
20
600
15
500
400
10
300
200
5
PREFERRED OPERATING RANGE
REYNOLDS NUMBER PER FOOT, RN_S
0
1
2
3
4
5
6
7
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
MACH NUMBER

6c. EIGHT-BY SEVEN-FOOT SUPERSONIC WIND TUNNEL

DESCRIPTION:

The Eight- by Seven-Foot Supersonic Wind Tunnel is a closed-return, variable-density tunnel equipped with a symmetrical, flexible-wall throat (the sidewalls are positioned by a series of jacks operated by hydraulic motors). The upper and lower surfaces are fixed. Airflow is produced by an eleven-stage, axial-flow compressor powered by four variable-speed wound-rotor induction motors.

For conventional, steady-state testing models are generally supported on a sting. Internal, strain-gage balances are used for measuring forces and moments. (Additional facilities are available for measuring multiple steady or fluctuating pressures.)

A schlieren system is available for studying flow patterns by direct viewing or photography, as well as a system for obtaining 20-by 20-inch shadowgraph negatives.

PERFORMANCE:

Mach Number	2.45 to 3.5 (continuously variable)
Stagnation Pressure	0.3 to 2.0 atmospheres
Reynolds Number	1.0×10^6 to 5.0×10^6 per foot
Stagnation Temperature	580° R

DIMENSIONS: Test Section

Height	8.0 feet
Width	7.0 feet
Length	16.0 feet
Access	Top hatch – 2.0 X 4.5 feet
	Side door – 8.0 X 10.0 feet

STATUS:

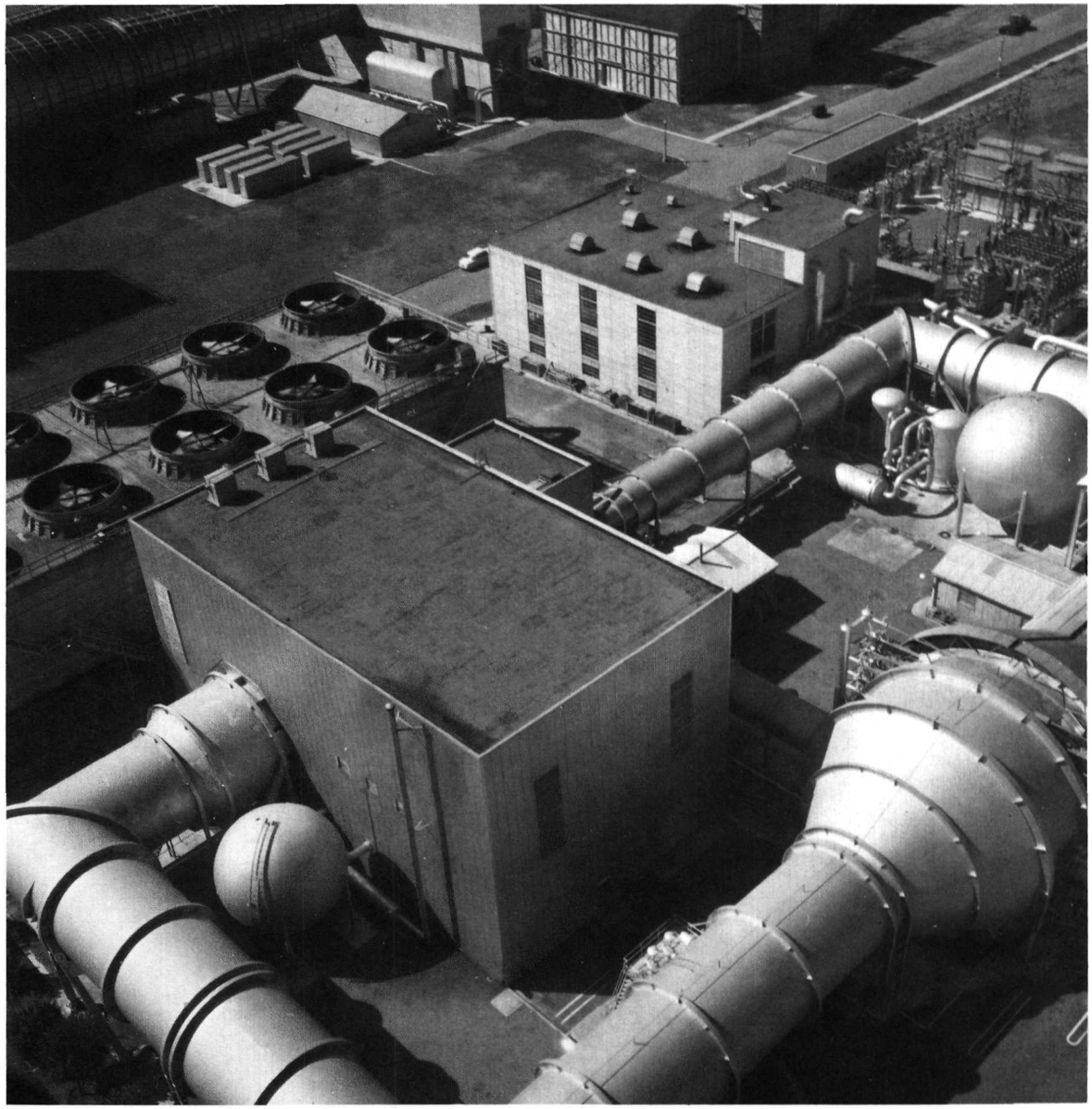
Operational since 1956

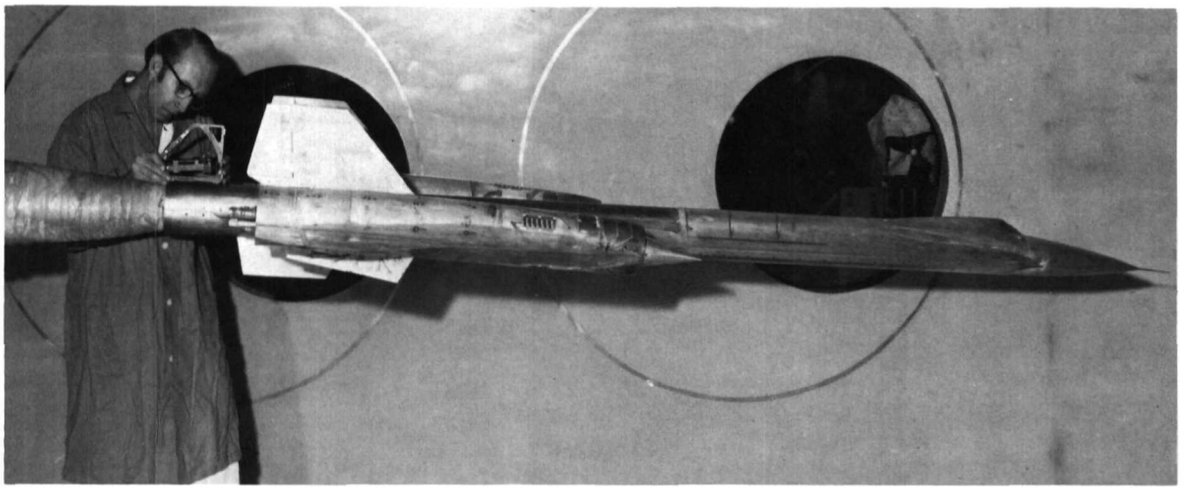
JURISDICTION:

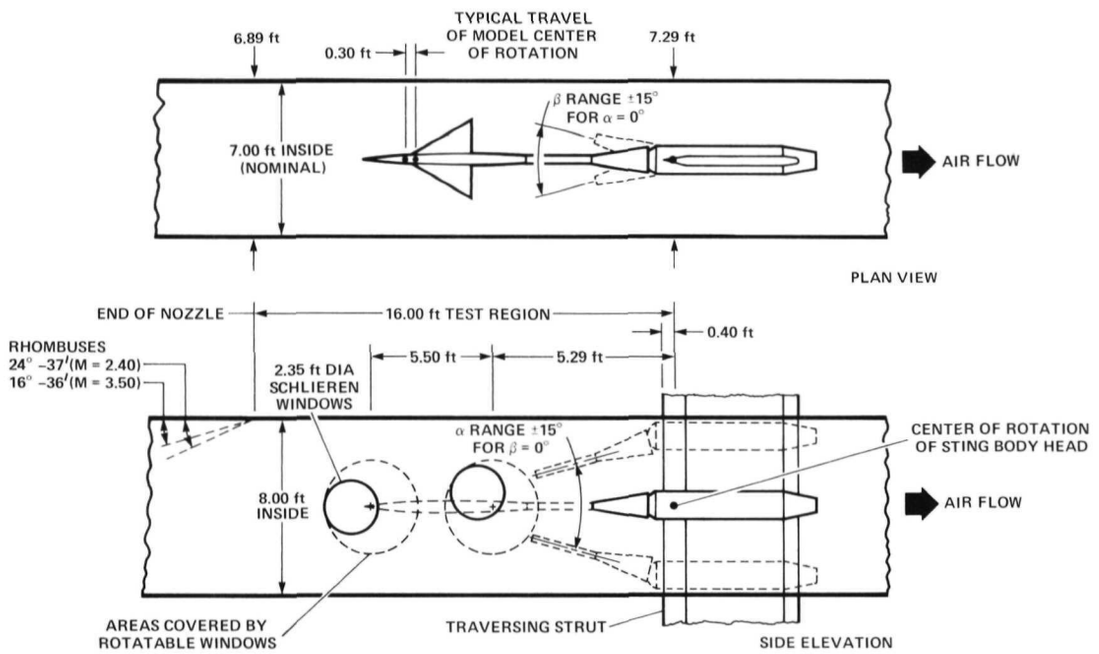
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

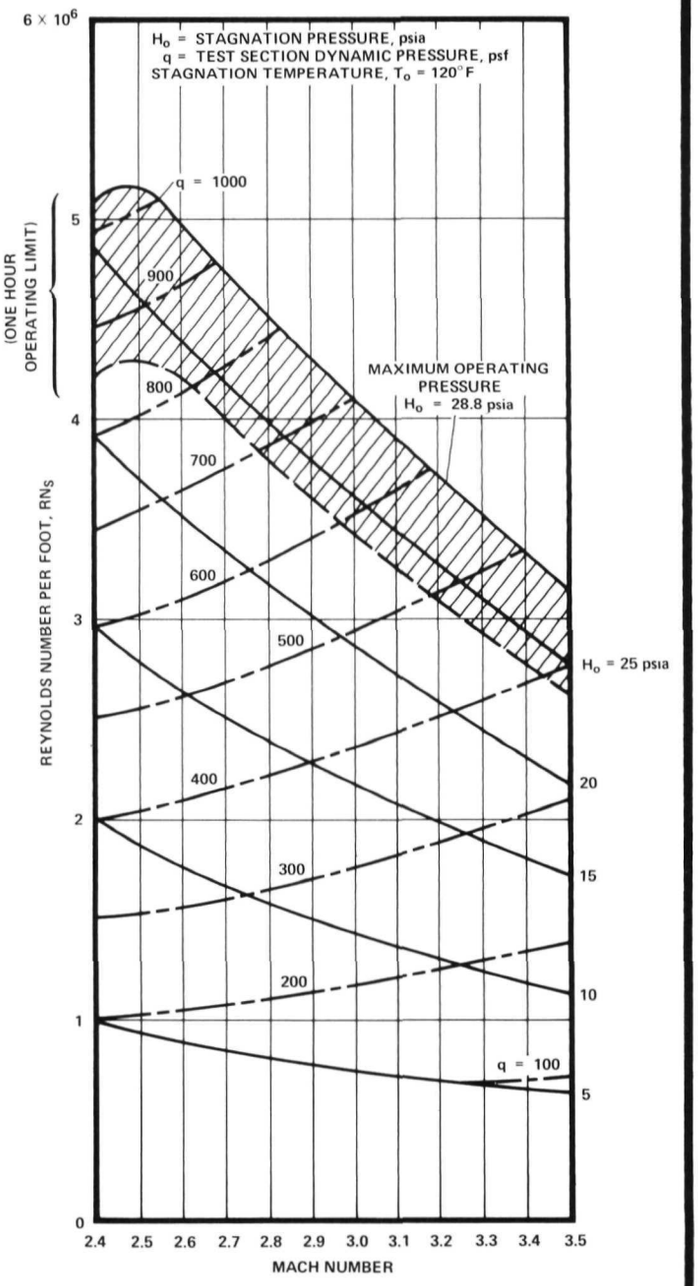
LOCATION:

Building N-227C






TYPICAL TRAVEL
OF MODEL CENTER
OF ROTATION
6.89 ft
0.30 ft
7.29 ft
β RANGE ±15°
FOR α = 0°
7.00 ft INSIDE
(NOMINAL)
AIR FLOW
PLAN VIEW
END OF NOZZLE
16.00 ft TEST REGION
0.40 ft
RHOMBUSES
24° -37′(M = 2.40)
16° -36′(M = 3.50)
2.35 ft DIA
SCHLIEREN
WINDOWS
5.50 ft
5.29 ft
α RANGE ±15°
FOR β = 0°
CENTER OF ROTATION
OF STING BODY HEAD
8.00 ft
INSIDE
AIR FLOW
AREAS COVERED BY
ROTATABLE WINDOWS
TRAVERSING STRUT
SIDE ELEVATION


6 × 10^6
H_o = STAGNATION PRESSURE, psia
q = TEST SECTION DYNAMIC PRESSURE, psf
STAGNATION TEMPERATURE, T_o = 120°F
q = 1000
900
800
700
600
500
400
300
200
q = 100
(ONE HOUR
OPERATING LIMIT)
MAXIMUM OPERATING
PRESSURE
H_o = 28.8 psia
H_o = 25 psia
REYNOLDS NUMBER PER FOOT, RN_S
MACH NUMBER
0
1
2
3
4
5
10
15
20
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5

7. SIX-BY SIX-FOOT SUPERSONIC WIND TUNNEL

DESCRIPTION:

The Six-by Six-Foot Supersonic Wind Tunnel is a closed-circuit, single-return tunnel equipped with an asymmetric sliding-block nozzle and a test section with a perforated floor and ceiling. Airflow is produced by an eight-stage, axial-flow compressor powered by two electric motors mounted in tandem outside the tunnel delivering a total of 60,000 horsepower.

For conventional, steady-state testing models are generally supported on a sting. Internal strain-gage balances are used for measuring forces and moments. (Additional facilities are available for measuring multiple steady or fluctuating pressures.)

A schlieren system is available for studying flow patterns by direct viewing or photography, as well as a system for obtaining 20-by 20-inch shadowgraph negatives.

PERFORMANCE:

Mach Number	0.25 to 2.2 (continuously variable)
Stagnation Pressure	0.3 to 1.0 atmospheres
Reynolds Number	1.0×10^6 to 5.0×10^6 per foot
Stagnation Temperature	580° R

DIMENSIONS: Test Section

Height	6.0 feet
Width	6.0 feet
Length	14.4 feet
Access	Side doors — 5.0 X 5.0 feet

STATUS:

Operational since 1948

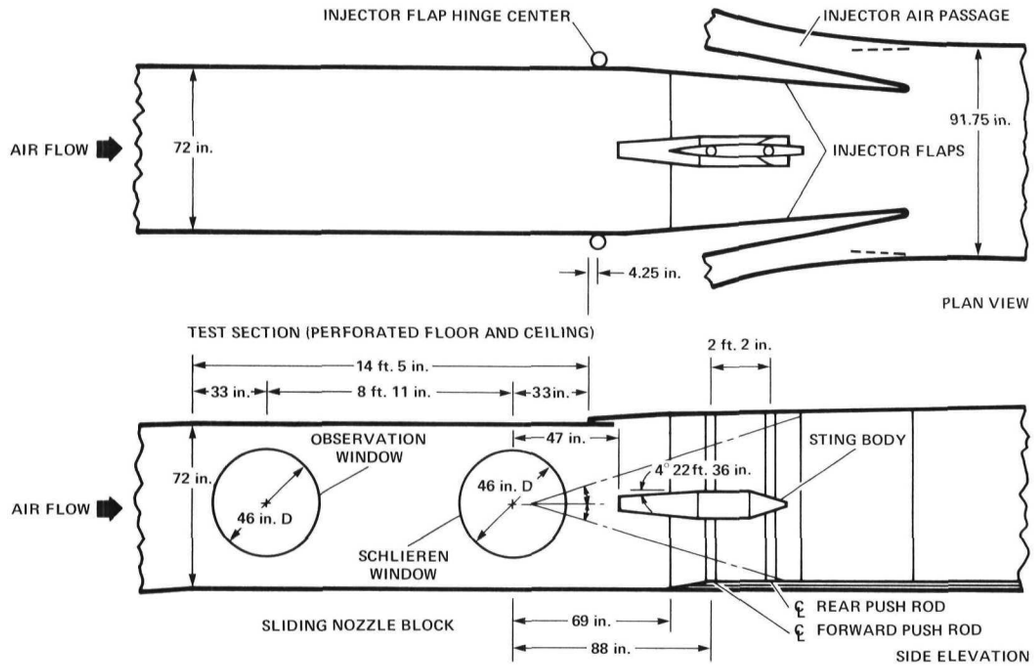
JURISDICTION:

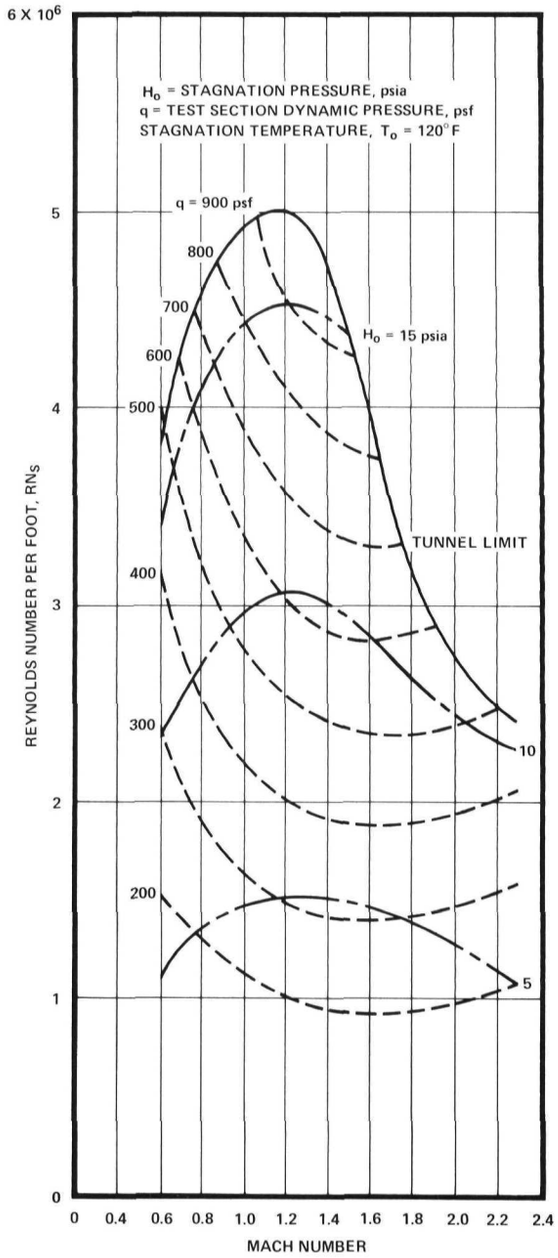
Aeronautics Division
Experimental Investigations Branch
Stuart Treon

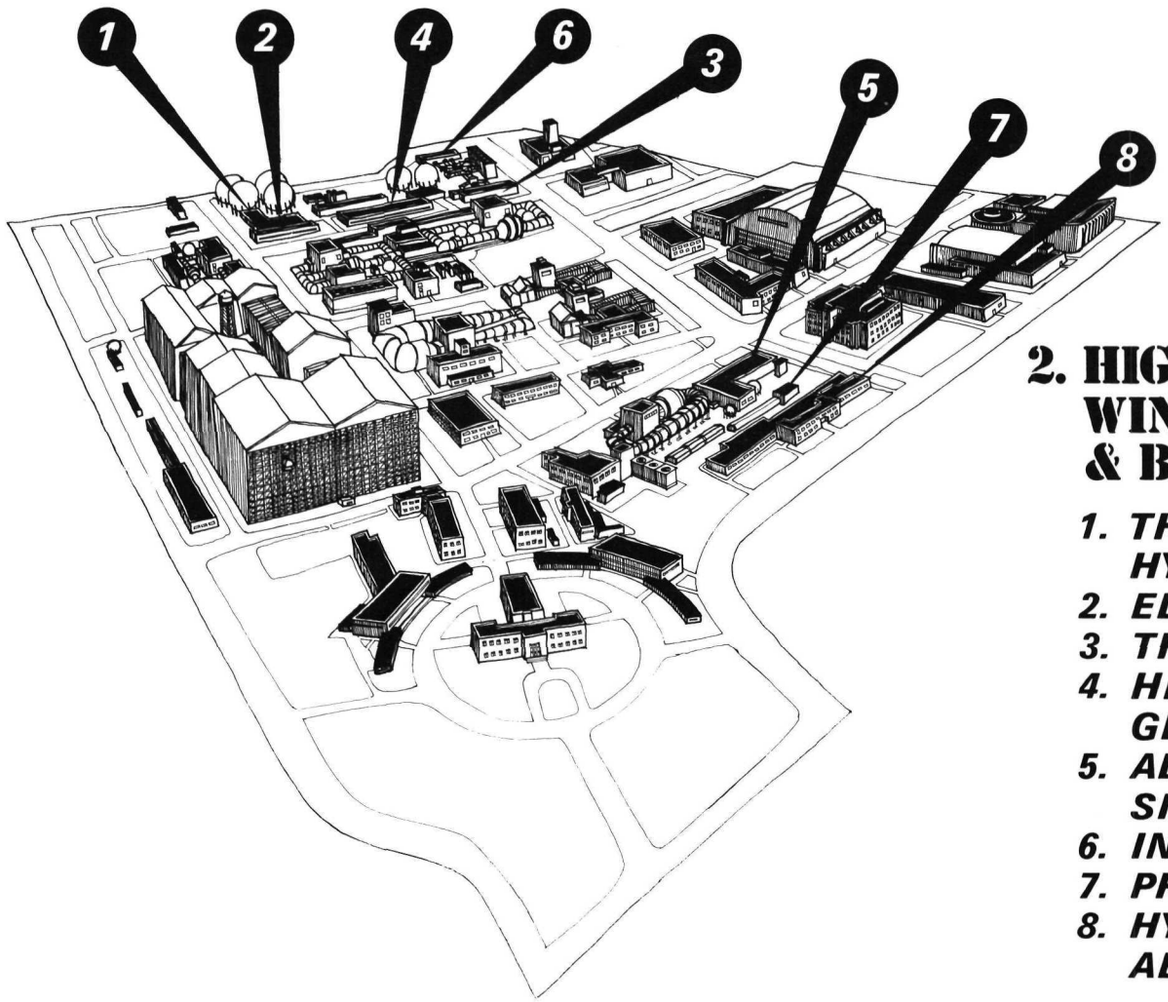
LOCATION:

Building N-226

NASA


INJECTOR FLAP HINGE CENTER
INJECTOR AIR PASSAGE
AIR FLOW
72 in.
91.75 in.
INJECTOR FLAPS
4.25 in.
PLAN VIEW
TEST SECTION (PERFORATED FLOOR AND CEILING)
14 ft. 5 in.
33 in.
8 ft. 11 in.
33in.
2 ft. 2 in.
OBSERVATION WINDOW
47 in.
STING BODY
72 in.
46 in. D
4° 22ft. 36 in.
AIR FLOW
46 in. D
SCHLIEREN WINDOW
SLIDING NOZZLE BLOCK
69 in.
88 in.
℄ REAR PUSH ROD
℄ FORWARD PUSH ROD
SIDE ELEVATION

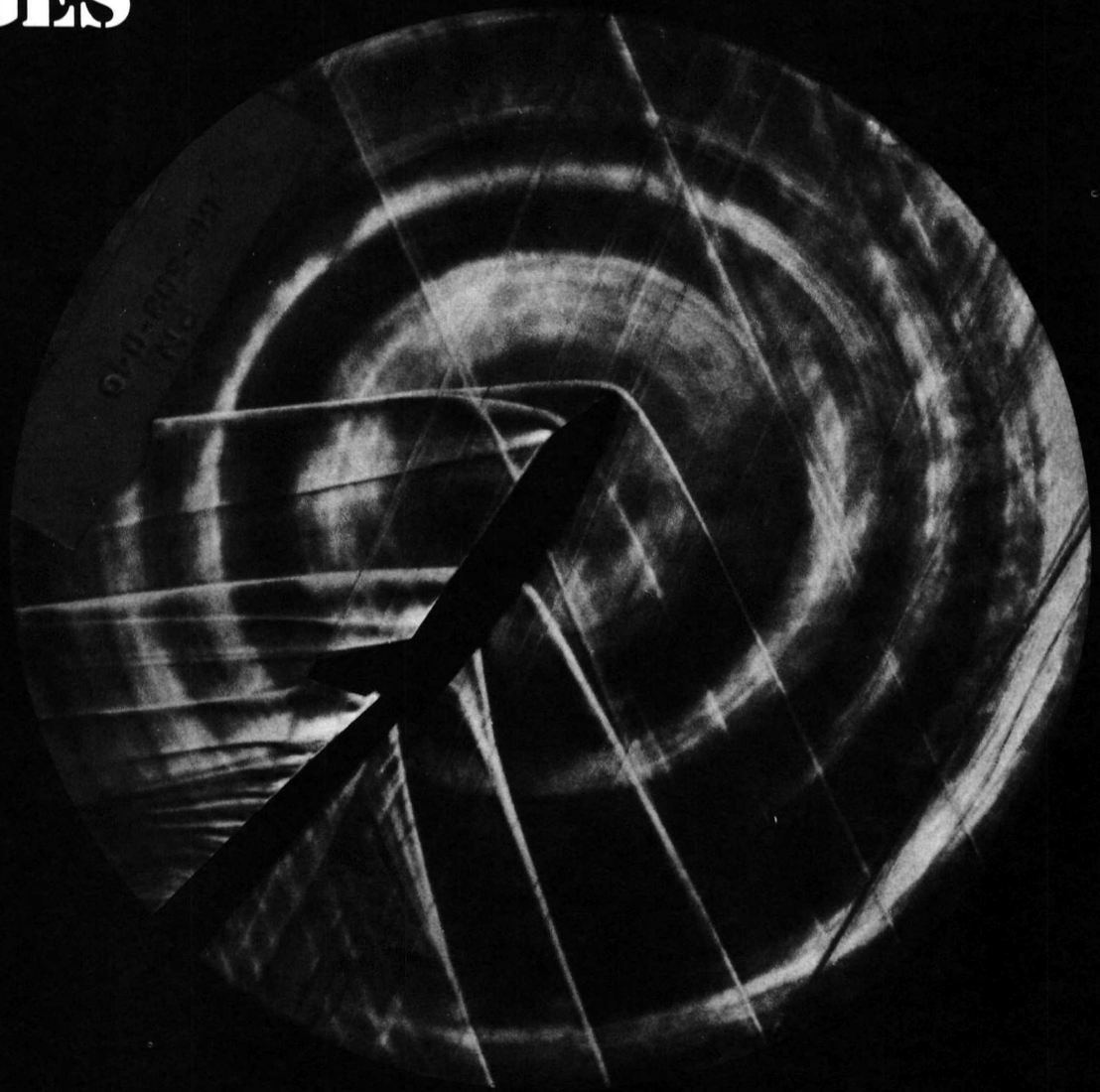

6 X 10^6
H_o = STAGNATION PRESSURE, psia
q = TEST SECTION DYNAMIC PRESSURE, psf
STAGNATION TEMPERATURE, T_o = 120°F
q = 900 psf
800
700
600
500
400
300
200
H_o = 15 psia
TUNNEL LIMIT
10
5
REYNOLDS NUMBER PER FOOT, RN_S
0
1
2
3
4
5
0 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4
MACH NUMBER



2. HIGH ENTHALPY & HYPERSONIC WIND TUNNELS, SHOCK TUBES, & BALLISTIC RANGES

1. *THREE AND ONE/HALF-FOOT HYPERSONIC WIND TUNNEL*
2. *ELECTRIC ARC SHOCK TUBE*
3. *THERMAL PROTECTION LABORATORY*
4. *HIGH POWER PULSED Nd: GLASS LASER*
5. *ADVANCED ENTRY HEATING SIMULATOR*
6. *INTERACTION HEATING FACILITY*
7. *PRESSURIZED BALLISTIC RANGE*
8. *HYPERSONIC FREE-FLIGHT AERODYNAMIC FACILITY*

2. HIGH ENTHALPY & HYPERSONIC WIND TUNNELS, SHOCK TUBES, & BALLISTIC RANGES



1. THREE AND ONE/HALF-FOOT HYPERSONIC WIND TUNNEL

DESCRIPTION:

The Three and One/Half-Foot Hypersonic Wind Tunnel is a closed circuit, blow-down, wind tunnel, utilizing interchangeable contoured axisymmetric nozzles. Heat is supplied to the test gas by a storage heater containing aluminum oxide pebbles which are heated by burning natural gas during the recycle period. Usable test time, dependent upon test conditions, varies from 1/2 to 3 minutes, and the time between test runs averages 1-1/2 hours. The test region is of the open jet type. The test chamber is a cylinder 12 feet in diameter and 48 feet in length, with the axis normal to the flow direction. The effective test section core is an open jet 3.5 feet in diameter and approximately 10 feet in length. A model support inserts and retracts models from the test stream and has a remotely actuated angle of attack range from –20 to +20 degrees. Shadowgraph and cameras are contained within the test chamber. Data are normally recorded in digital form on magnetic tape at a rate of 2500 samples per second.

PERFORMANCE:

Mach numbers	5, 7, 10 and 14
Reynolds number	0.3×10^6 to 7.4×10^6/ft
Dynamic pressure	1,600 psf, maximum
Stagnation pressure	122 atmospheres, maximum
Stagnation temperature	3,460° R, maximum

DIMENSIONS: Test Section (Core)

Length	10 feet
Diameter	3.5 feet

STATUS:

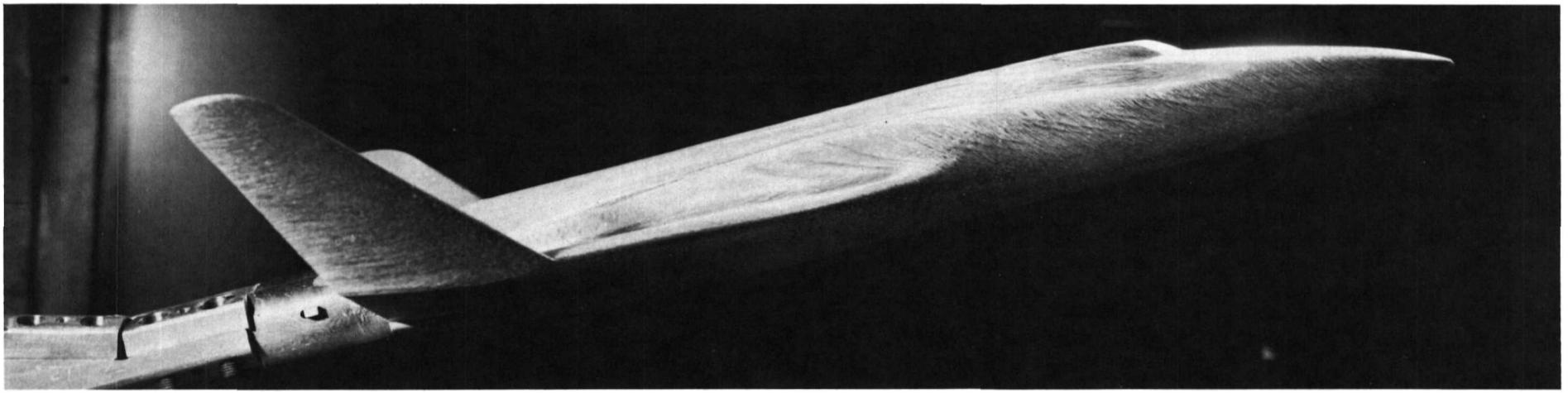
Operational since 1961, refurbished in 1972.

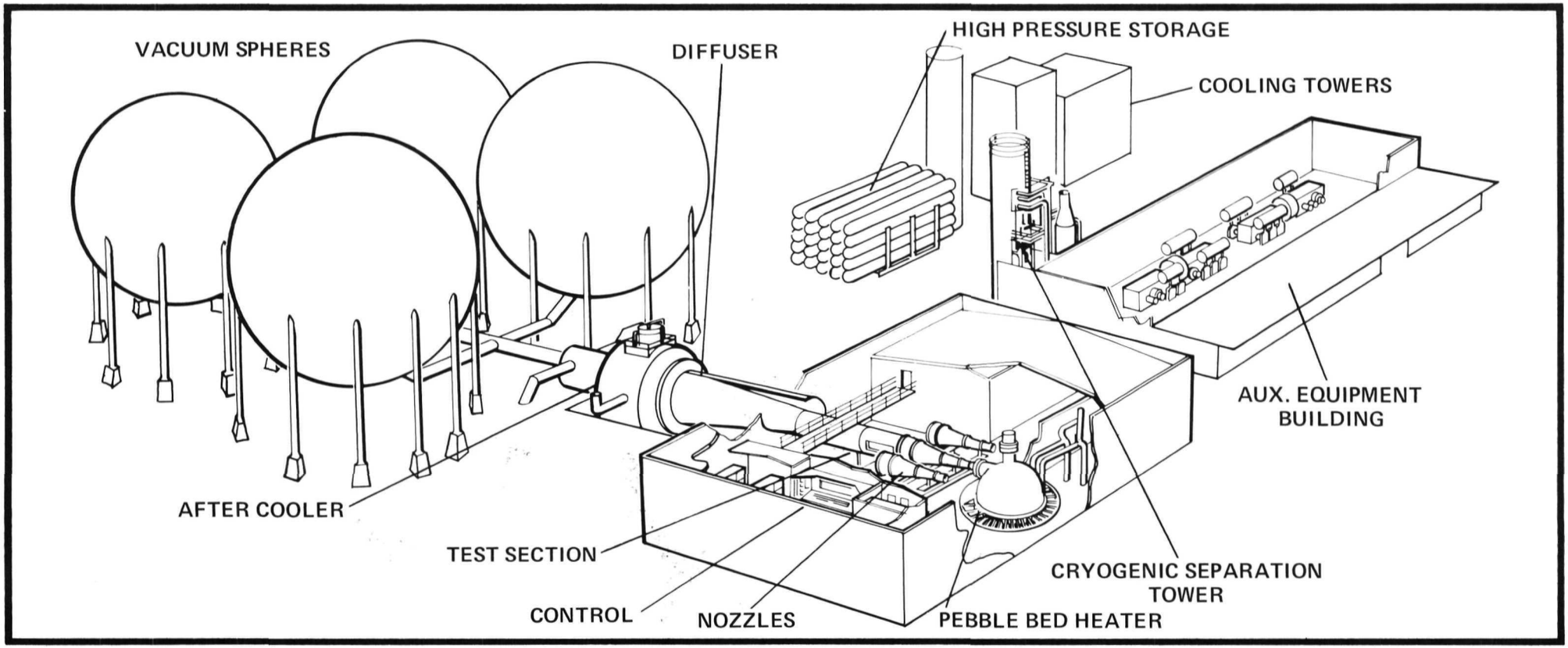
JURISDICTION:

Thermo-and Gas-Dynamics Division
Experimental Fluid Dynamics Branch
Joseph G. Marvin

LOCATION:

Building N-229




VACUUM SPHERES
DIFFUSER
HIGH PRESSURE STORAGE
COOLING TOWERS
AUX. EQUIPMENT BUILDING
AFTER COOLER
TEST SECTION
CONTROL
NOZZLES
CRYOGENIC SEPARATION TOWER
PEBBLE BED HEATER

2. ELECTRIC ARC SHOCK TUBE

DESCRIPTION:

The Electric Arc Shock Tube Facility is used for investigations such as gas laser development, radiation and ionization studies for outer planetary entries, chemical reaction rate measurements, and diagnostics in high-energy flows requiring a high-performance electric arc driven shock tube facility. Shock velocities of 30 to 40 km/sec. can be attained with quick succession operation (3-5 tests per day) utilizing the conical arc chamber. Energy for the driver is supplied by a one-megajoule capacitor storage system. It can be charged to a preset energy at either a 0 to 40 kV mode (1,250 μf) or a 0 to 20 kV mode (5,000 μf). The unique capability to change circuit capacitance for a particular energy storage permits control of the current pulse width (time constant) of the arc discharge.

DIMENSIONS:

Length	40 ft.
Diameter	4 inches

STATUS:

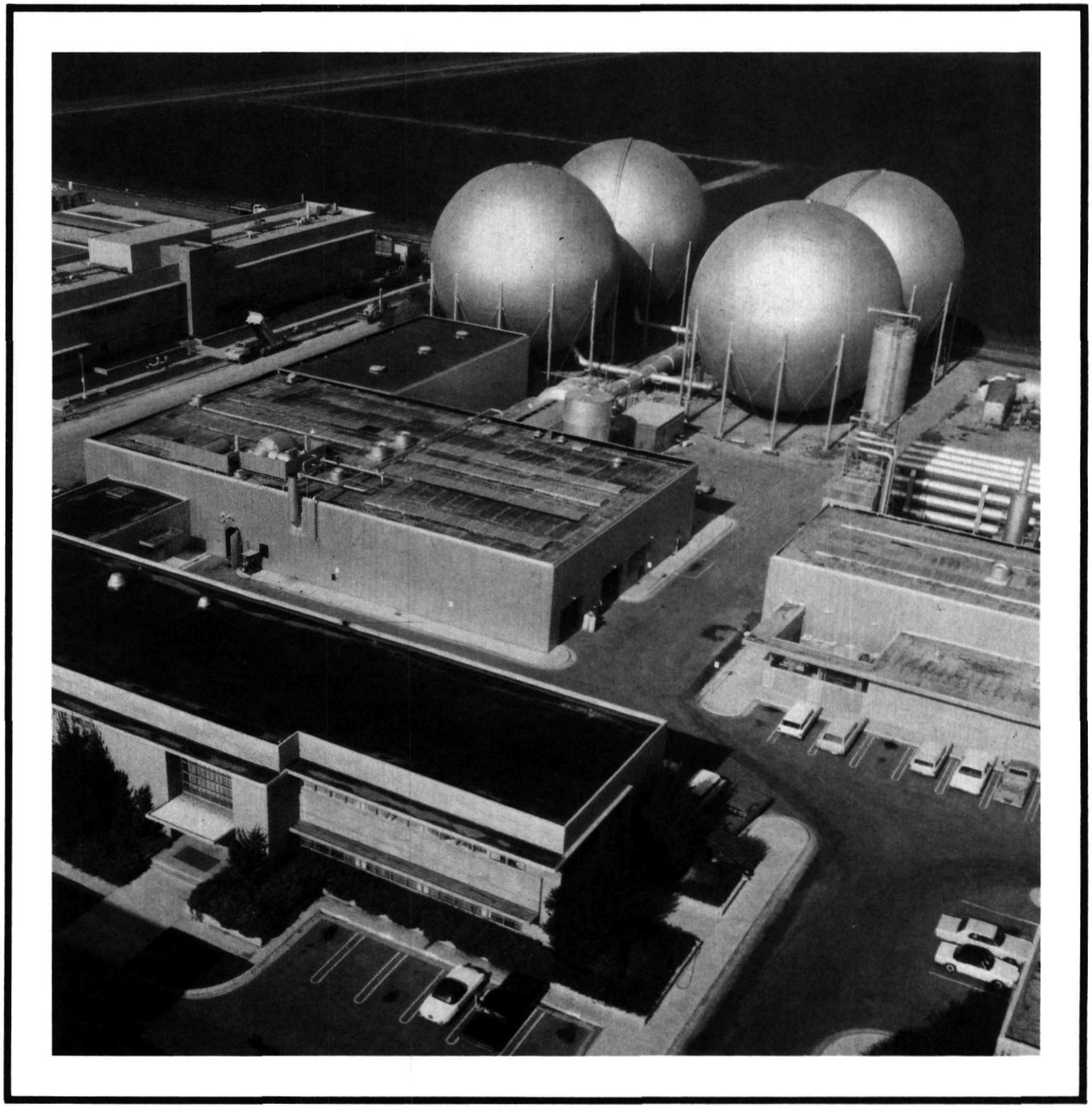
Operational since 1966

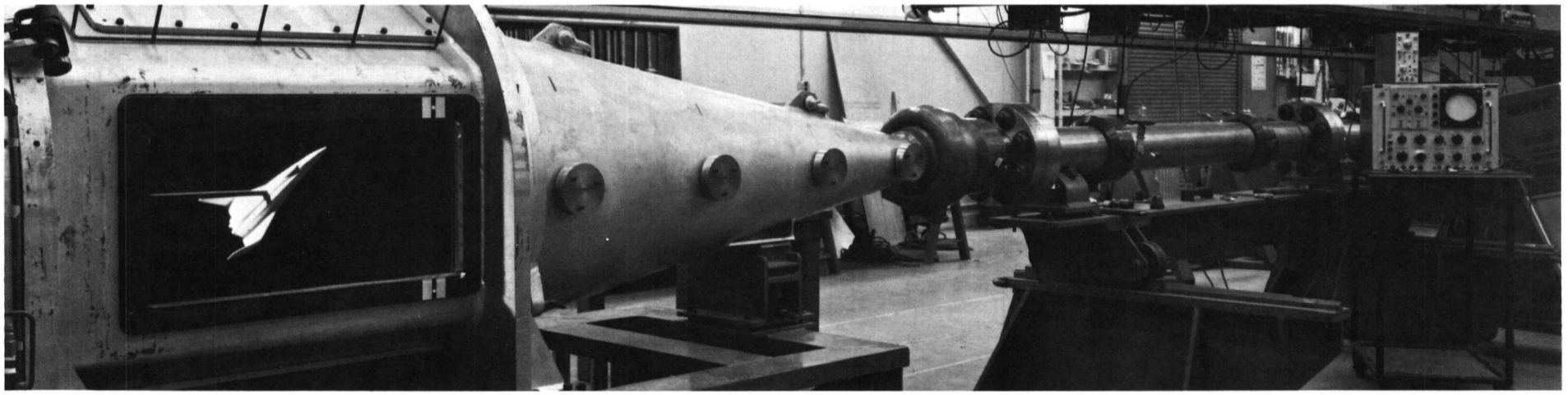
JURISDICTION:

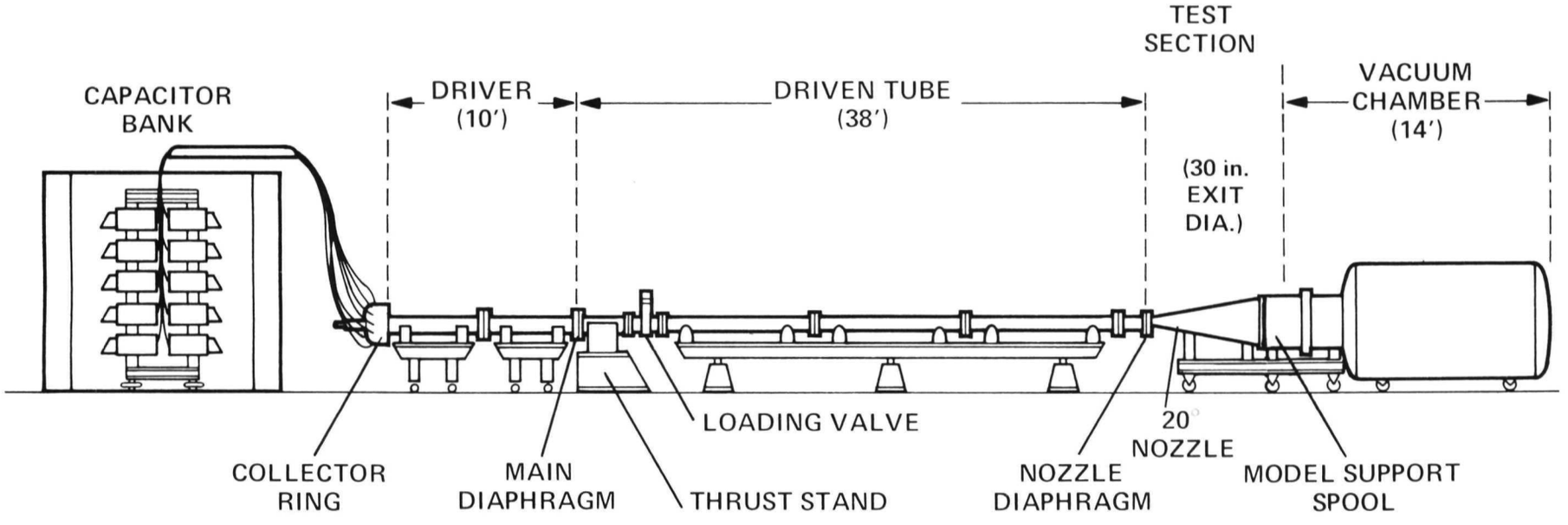
Thermo-and Gas-Dynamics Division
Physical Gas Dynamics and Lasers Branch
C. Frederick Hansen

LOCATION:

Building N-229






TEST
SECTION
VACUUM
CHAMBER
(14')
CAPACITOR
BANK
DRIVER
(10')
DRIVEN TUBE
(38')
(30 in.
EXIT
DIA.)
LOADING VALVE
20°
NOZZLE
COLLECTOR
RING
MAIN
DIAPHRAGM
THRUST STAND
NOZZLE
DIAPHRAGM
MODEL SUPPORT
SPOOL

3. THERMAL PROTECTION LABORATORY

DESCRIPTION:

The Thermal Protection Laboratory is used to research materials for heat shield applications and for aerodynamic heating and materials studies of vehicles in planetary atmospheres. This laboratory is comprised of five separate facilities: an Aerodynamic Heating Tunnel, a Heat Transfer Tunnel, two Supersonic Turbulent Ducts, and a High-Power CO_2 Gasdynamic Laser. All these facilities are driven by arc-heaters, with the exception of the large, combustion-type laser. The arc-heated facilities are powered by a 20 Megawatt DC power supply. Their effluent gas stream (test gases; Air, N_2, He, CO_2, and mixtures; flow rates from 0.05 to 5.0 lbs/sec) discharges into a five-stage steam-ejector-driven vacuum system. The vacuum system and power supply are common to the test facilities in Building N-238. All of the facilities have high pressure water available at flow rates up to 4,000 gals/min. The data obtained from these facilities are recorded on magnetic tape or oscillographs. All forms of data can be handled whether from thermocouples, pressure cells, pyrometers, or radiometers, etc. In addition, closed circuit T.V. monitors and various film cameras are available.

STATUS:

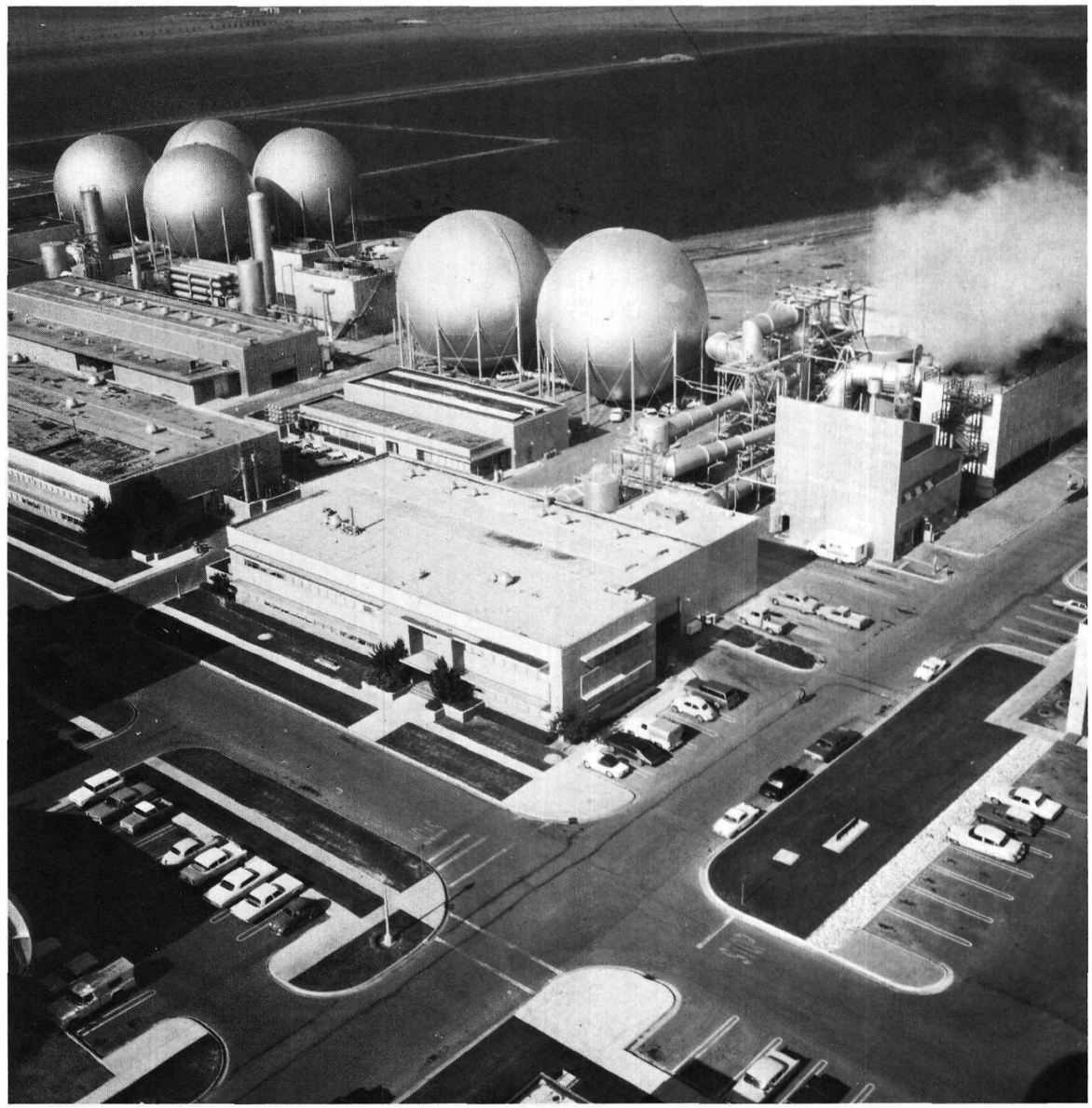
Operational since 1962

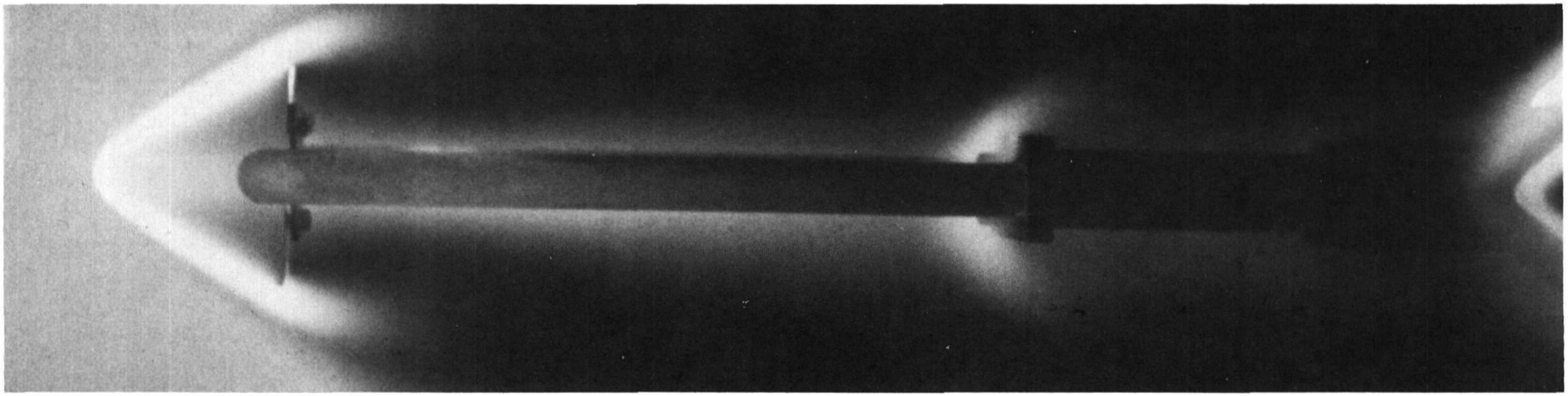
JURISDICTION:

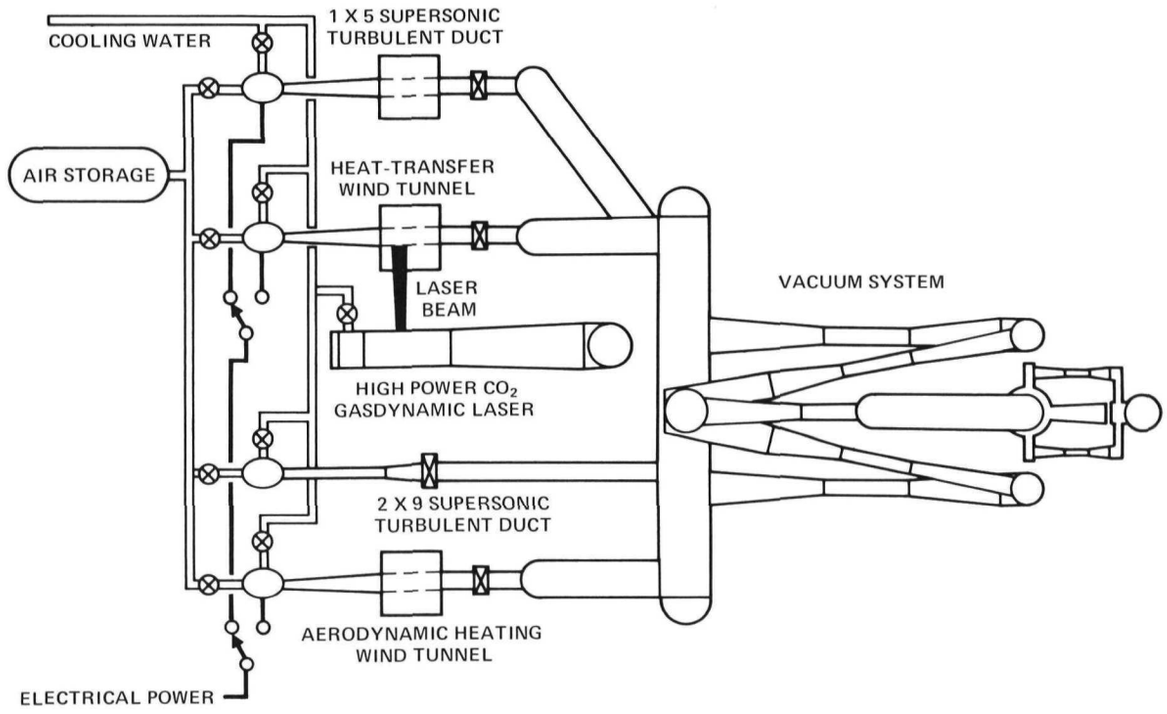
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-234






COOLING WATER
1 X 5 SUPERSONIC TURBULENT DUCT
AIR STORAGE
HEAT-TRANSFER WIND TUNNEL
LASER BEAM
VACUUM SYSTEM
HIGH POWER CO_2 GASDYNAMIC LASER
2 X 9 SUPERSONIC TURBULENT DUCT
AERODYNAMIC HEATING WIND TUNNEL
ELECTRICAL POWER

3a. AERODYNAMIC HEATING TUNNEL

DESCRIPTION:

The Aerodynamic Heating Tunnel is a hypersonic wind tunnel, driven by arc-heaters with powers up to 20 Megawatts. This tunnel has a wide range of operating characteristics, and utilizes an extensive variety of nozzle configurations. Nozzle exit diameters up to 36 inches, and throat diameters up to two inches are available. Models with specimen diameters up to ten inches can be accommodated. Two support systems are available: an angle of attack system (which is controllable through ±60 degrees), and a traversing system mounted on the test section floor (suitable for either surveying or model support). Run time is continuous.

PERFORMANCE:

Stream Enthalpy	500 to 15,000 BTU/lb.
Mach Number	3 to 15 (variable)
Stagnation Pressure	0.005 to 5.0 atmospheres
Plenum Pressure	1,200 psi, maximum

STATUS:

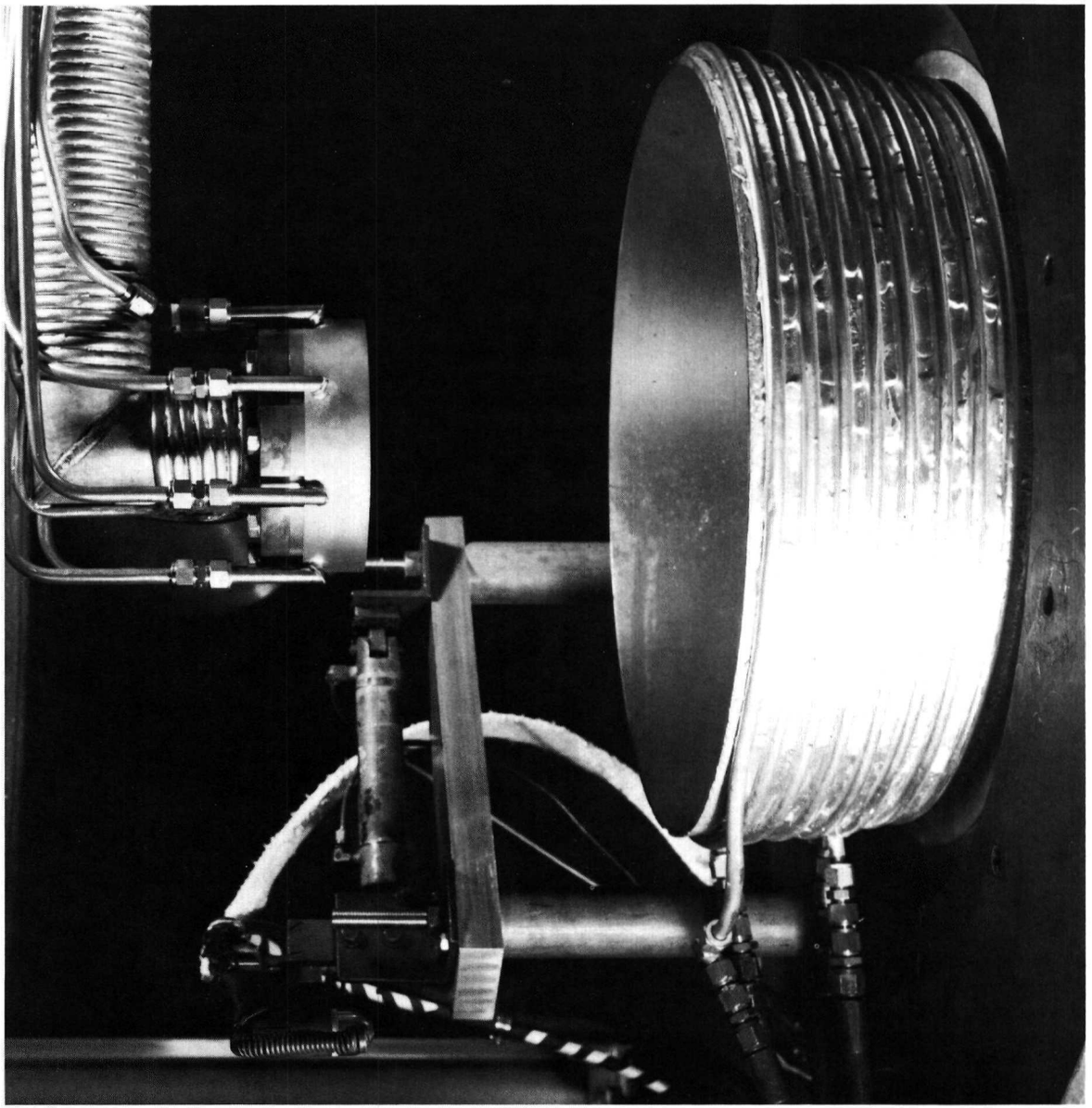
Operational since 1962

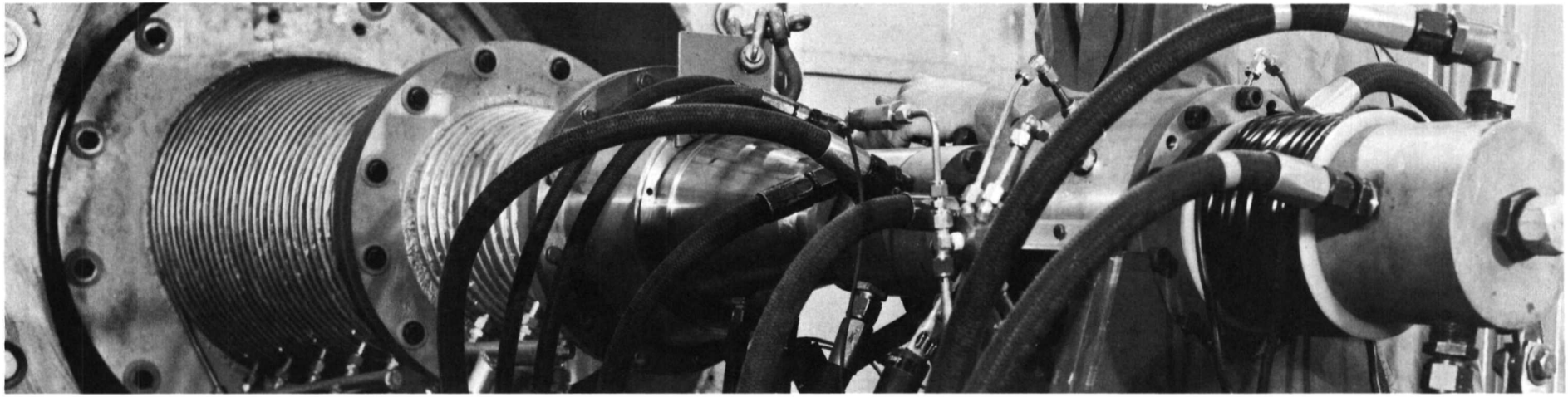
JURISDICTION:

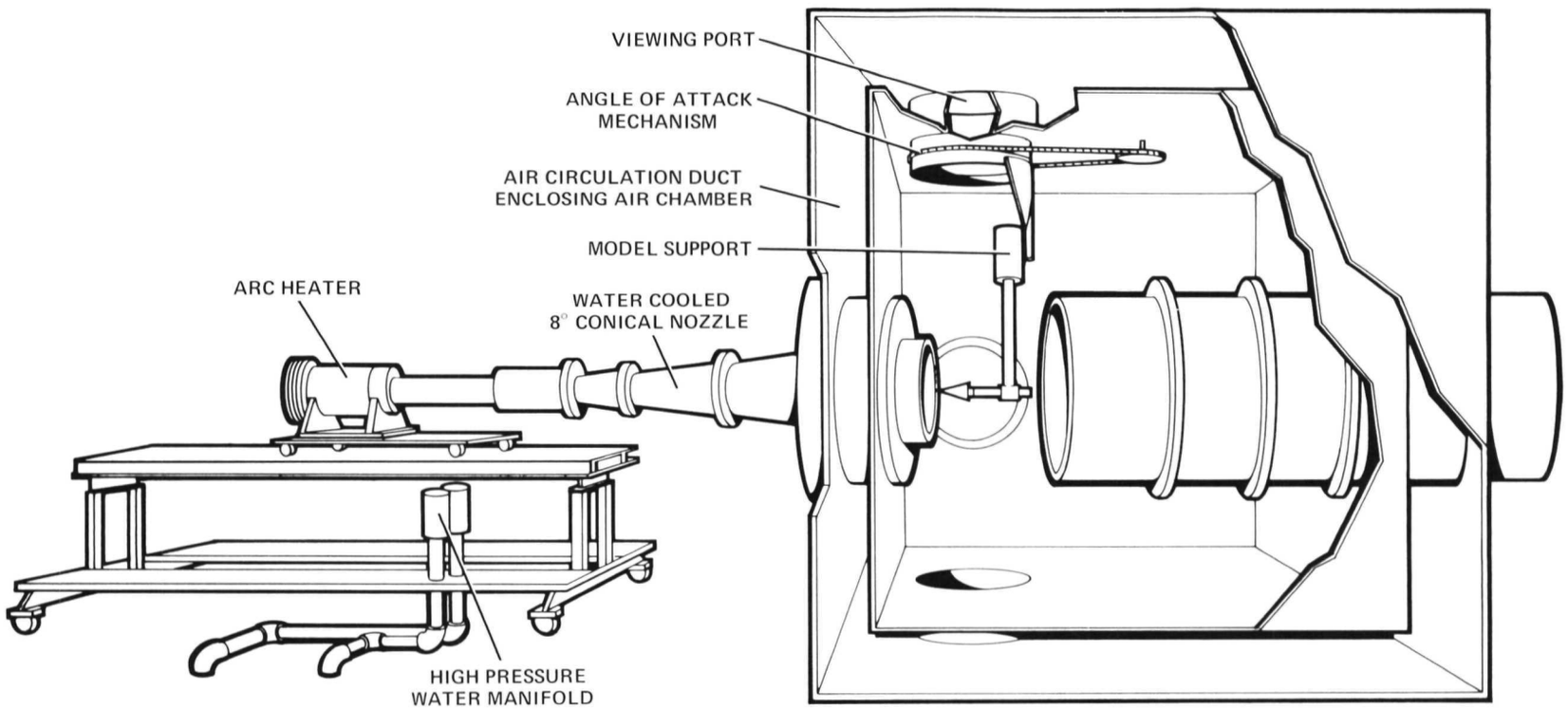
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-234






VIEWING PORT
ANGLE OF ATTACK MECHANISM
AIR CIRCULATION DUCT ENCLOSING AIR CHAMBER
MODEL SUPPORT
ARC HEATER
WATER COOLED 8° CONICAL NOZZLE
HIGH PRESSURE WATER MANIFOLD

3b. HEAT TRANSFER TUNNEL

DESCRIPTION:

The Heat Transfer Tunnel is a hypersonic wind tunnel driven by two different four megawatt arc-heaters. This tunnel has a wide range of operating characteristics, and utilizes an extensive variety of nozzle configurations. Nozzle exit diameters up to 24 inches, and throat diameters up to a diameter of one inch are available. Models with specimen diameters up to six inches can be accommodated. The model support system can handle a total of 18 models with diameters up to two inches (a lesser number of models with larger diameters can be accommodated). Support arms are arranged radially, and models are inserted into the effluent gas stream and retracted in sequence by a series of linear motion actuators. Run-time is ten minutes.

PERFORMANCE:

Stream Enthalpy	1,500 to 15,000 BTU/lb.
Mach Number	2.5 to 15 (variable)
Stagnation Pressure	0.01 to 9.0 atmospheres
Plenum Pressure	1,000 psi, maximum

STATUS:

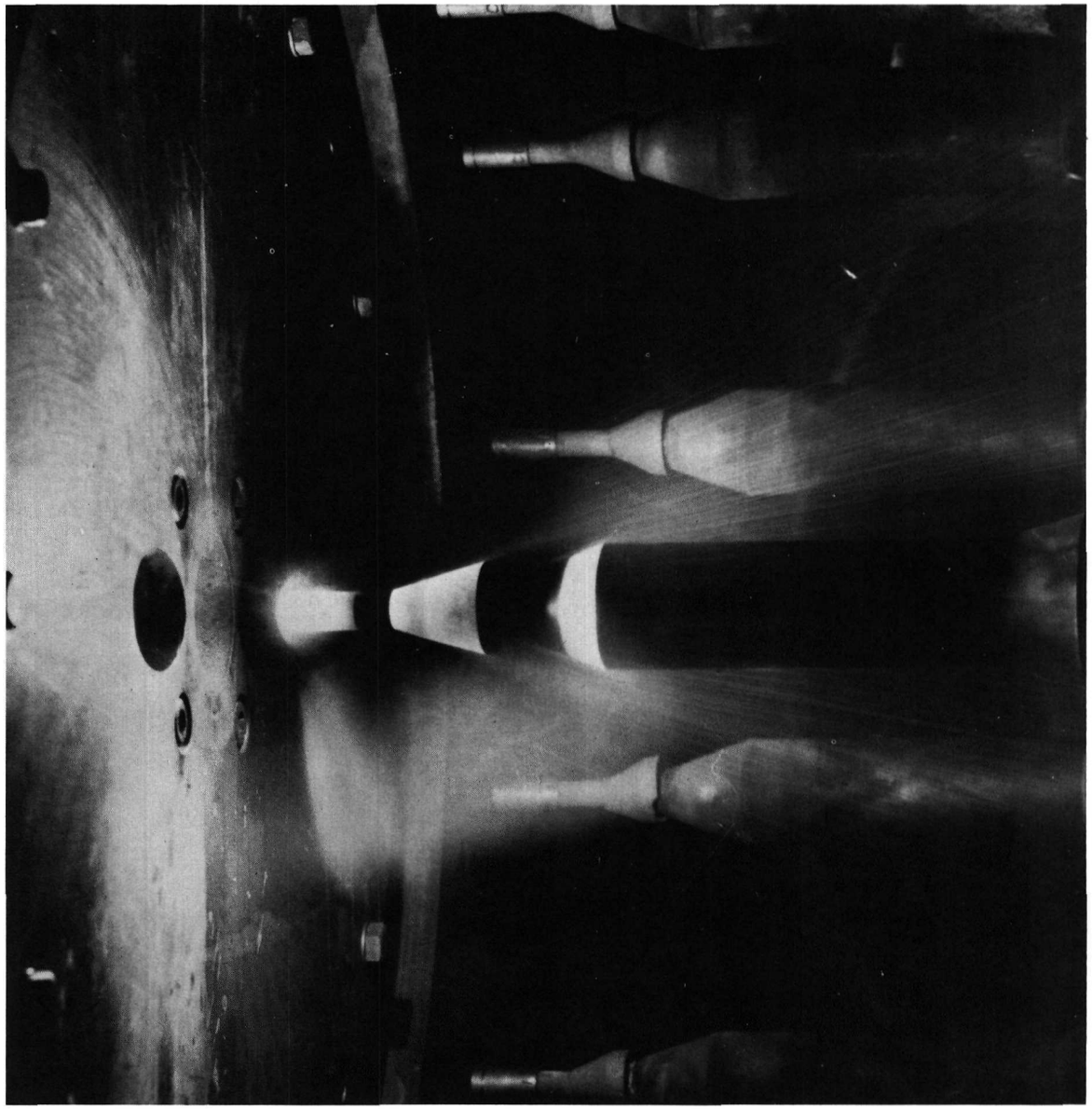
Operational since 1962

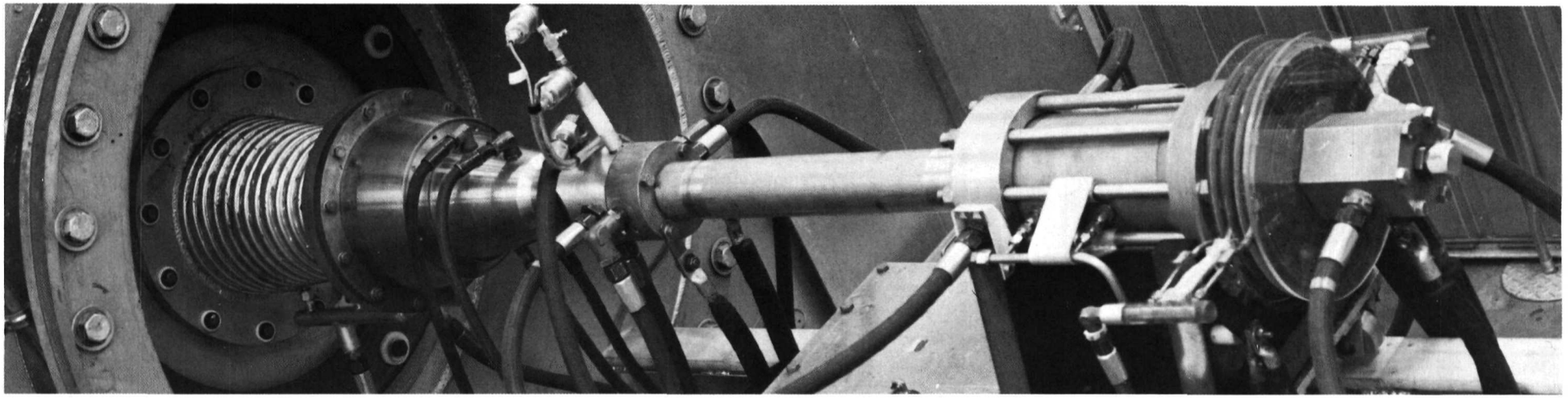
JURISDICTION:

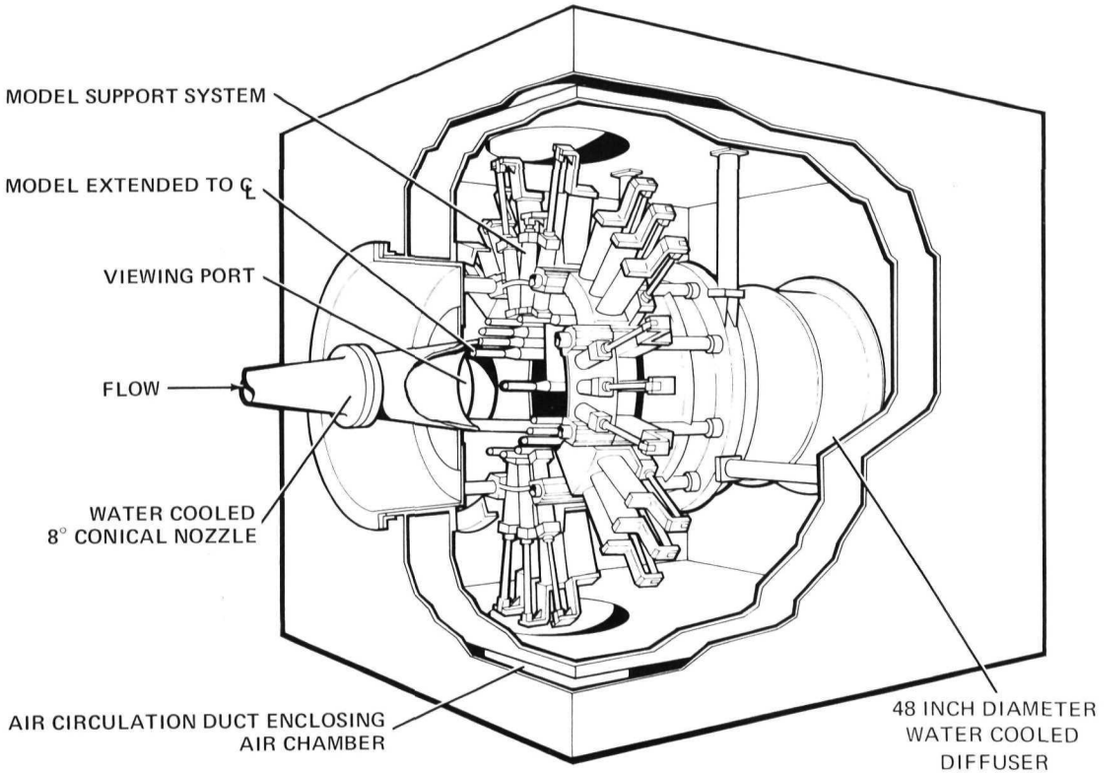
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-234






MODEL SUPPORT SYSTEM
MODEL EXTENDED TO ℄
VIEWING PORT
FLOW
WATER COOLED
8° CONICAL NOZZLE
AIR CIRCULATION DUCT ENCLOSING
AIR CHAMBER
48 INCH DIAMETER
WATER COOLED
DIFFUSER

3c. ONE-BY-FIVE INCH AND TWO-BY-NINE INCH SUPERSONIC TURBULENT FLOW DUCTS

DESCRIPTION:

The One-by-Five Inch and Two-by-Nine Inch Supersonic Turbulent Flow Ducts are used to study highly active turbulent two-dimensional fluid flows over a flat surface. Both ducts are rectangular; the One-by-Five Inch Duct can accommodate models four inches wide by six inches long, and the Two-by-Nine Inch Duct can accommodate models eight inches wide by ten and twenty inches long, and any desired depth. Wall heating rates, wall pressures, model surface temperature from thermocouples and optical pyrometers, as well as arc-heater operating data may be obtained. Run-times are continuous for both ducts.

PERFORMANCE: One-by-Five Inch Duct

Stream Enthalpy	700 to 5,000 BTU/lb.
Mach Number	3.4
Wall pressure	0.02 to 0.30 atmospheres
Wall heating rate	2 to 130 BTU/ft^2-sec
Plenum pressure	1 to 45 atmospheres

PERFORMANCE: Two-by-Nine Inch Duct

Stream Enthalpy	1,500 to 4,000 BTU/lb.
Mach Number	3.4 (nominal)
Wall pressure	0.02 to 0.15 atmospheres
Wall heating rate	2 to 60 BTU/ft^2-sec
Plenum pressure	2 to 15 atmospheres

STATUS:

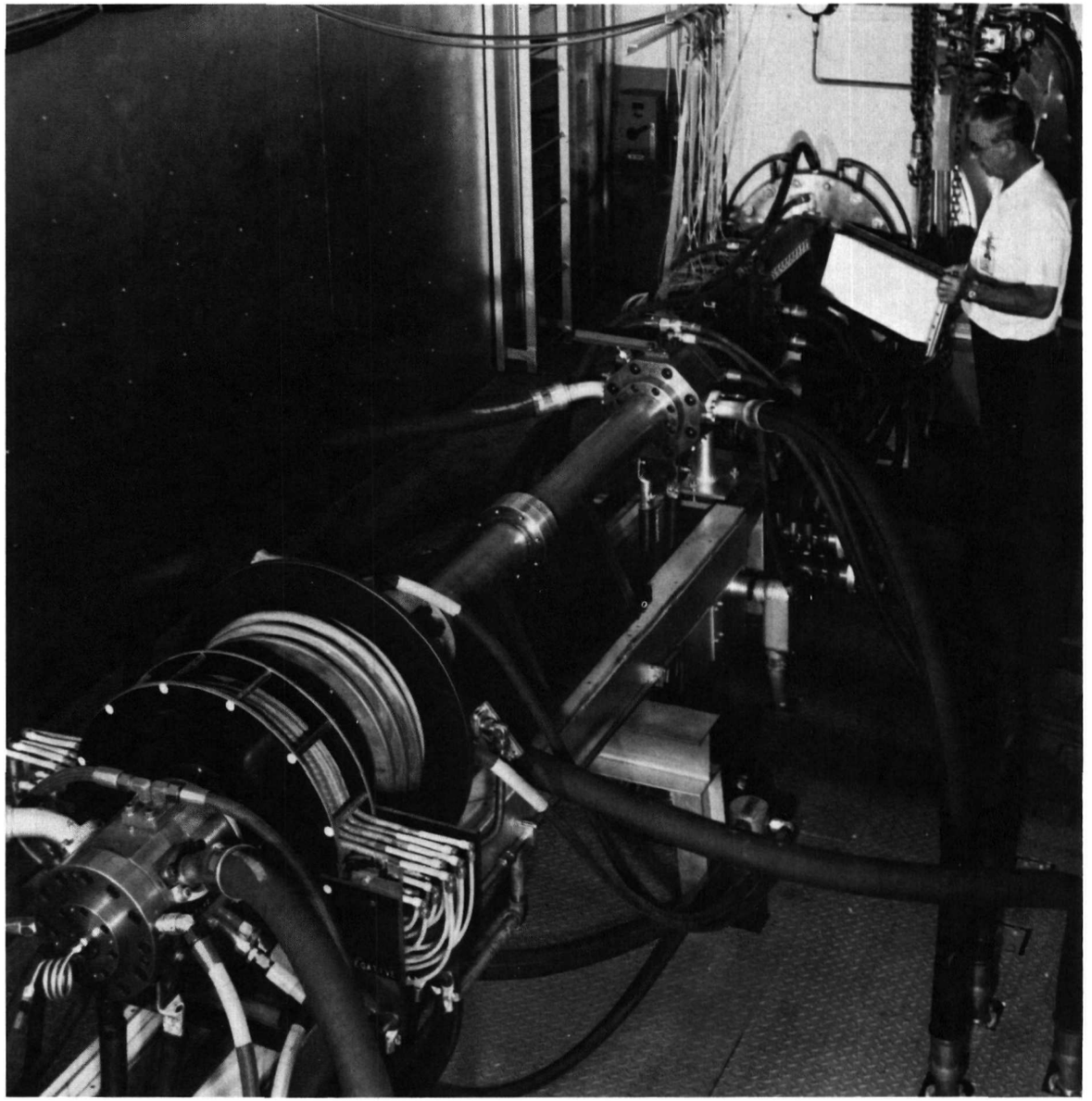
Operational since 1969 and 1972, respectively

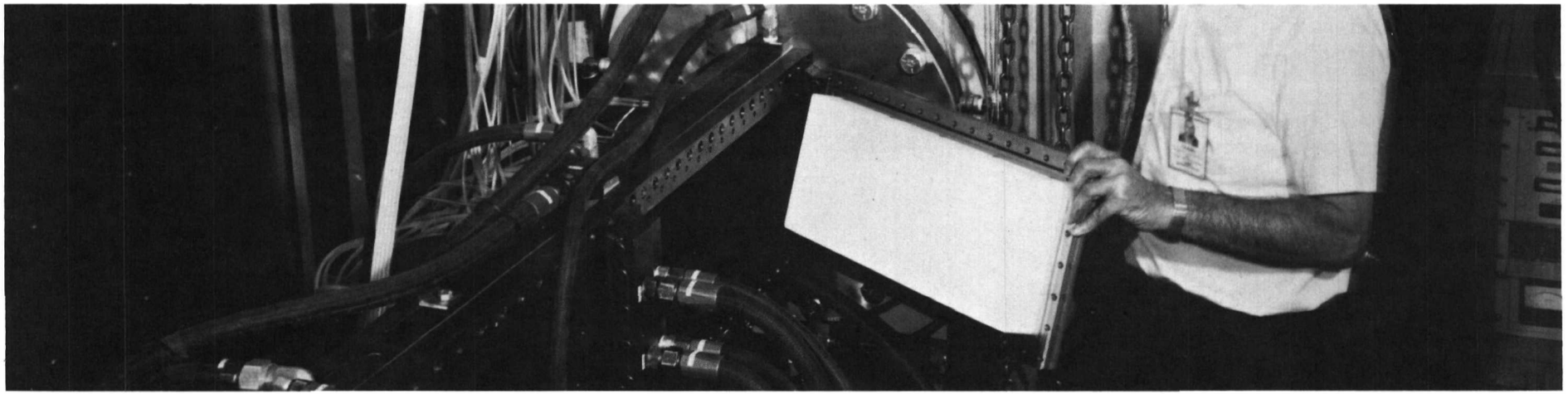
JURISDICTION:

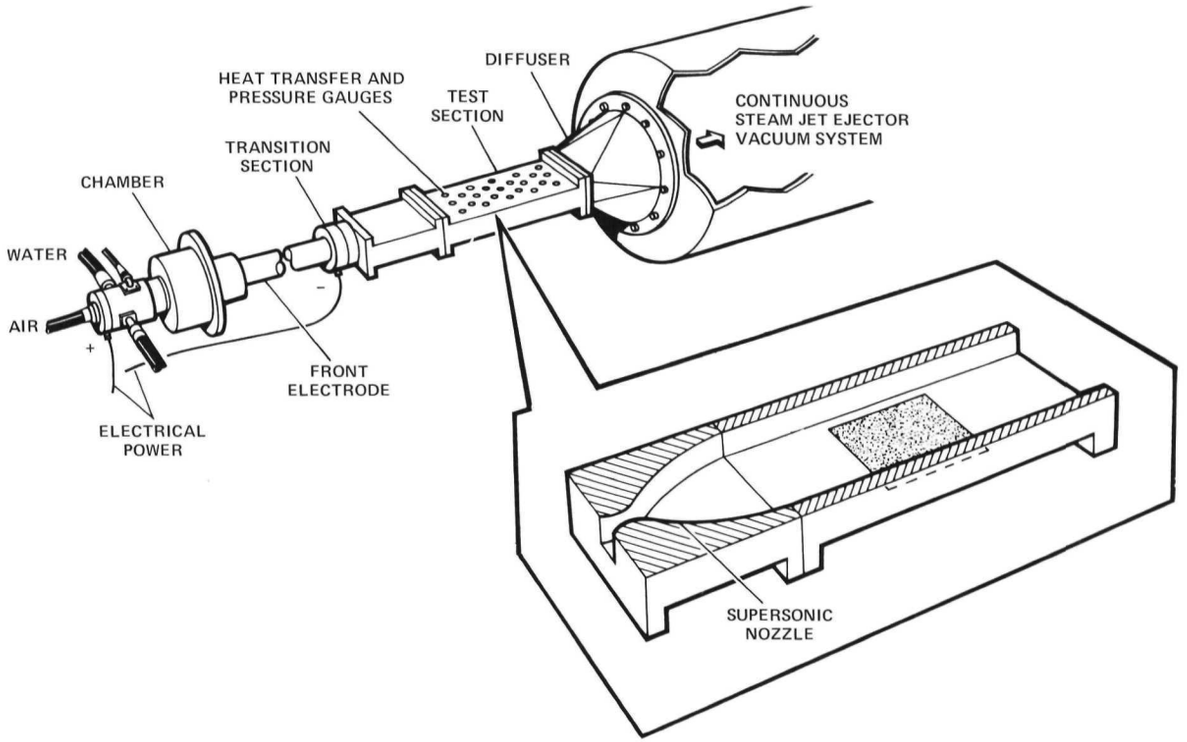
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-234






DIFFUSER
HEAT TRANSFER AND
PRESSURE GAUGES
TEST
SECTION
CONTINUOUS
STEAM JET EJECTOR
VACUUM SYSTEM
TRANSITION
SECTION
CHAMBER
WATER
AIR
+
-
FRONT
ELECTRODE
ELECTRICAL
POWER
SUPERSONIC
NOZZLE

3d. HIGH-POWER CO_2 GASDYNAMIC LASER

DESCRIPTION:

The High-Power CO_2 Gasdynamic Laser is a combustion driven laser capable of producing radiative energy at a wavelength of 10.6 microns. It can be configured in two modes; with an unstable resonator cavity, and a stable multi-mode cavity. The uniformity and power available from either configuration is variable depending on the optics used to focus and position the beam. The beam generated by the unstable resonator can be manipulated much more readily than the output beam from the multi-mode cavity. In addition, the beam generated by the unstable resonator can be transferred into the test section of the Heat Transfer Tunnel allowing a test section specimen to be exposed to both an arc-heated gas stream and a radiative beam.

PERFORMANCE:

Power available at target	
Unstable resonator	0.0 to 30.0 KW
Multi-mode resonator	0.0 to 70.0 KW
Target diameters	
Unstable resonator	0.50 to 10.0 cm
Multi-mode resonator	2.0 to 10.0 cm
Target test time	15 sec, maximum

STATUS:

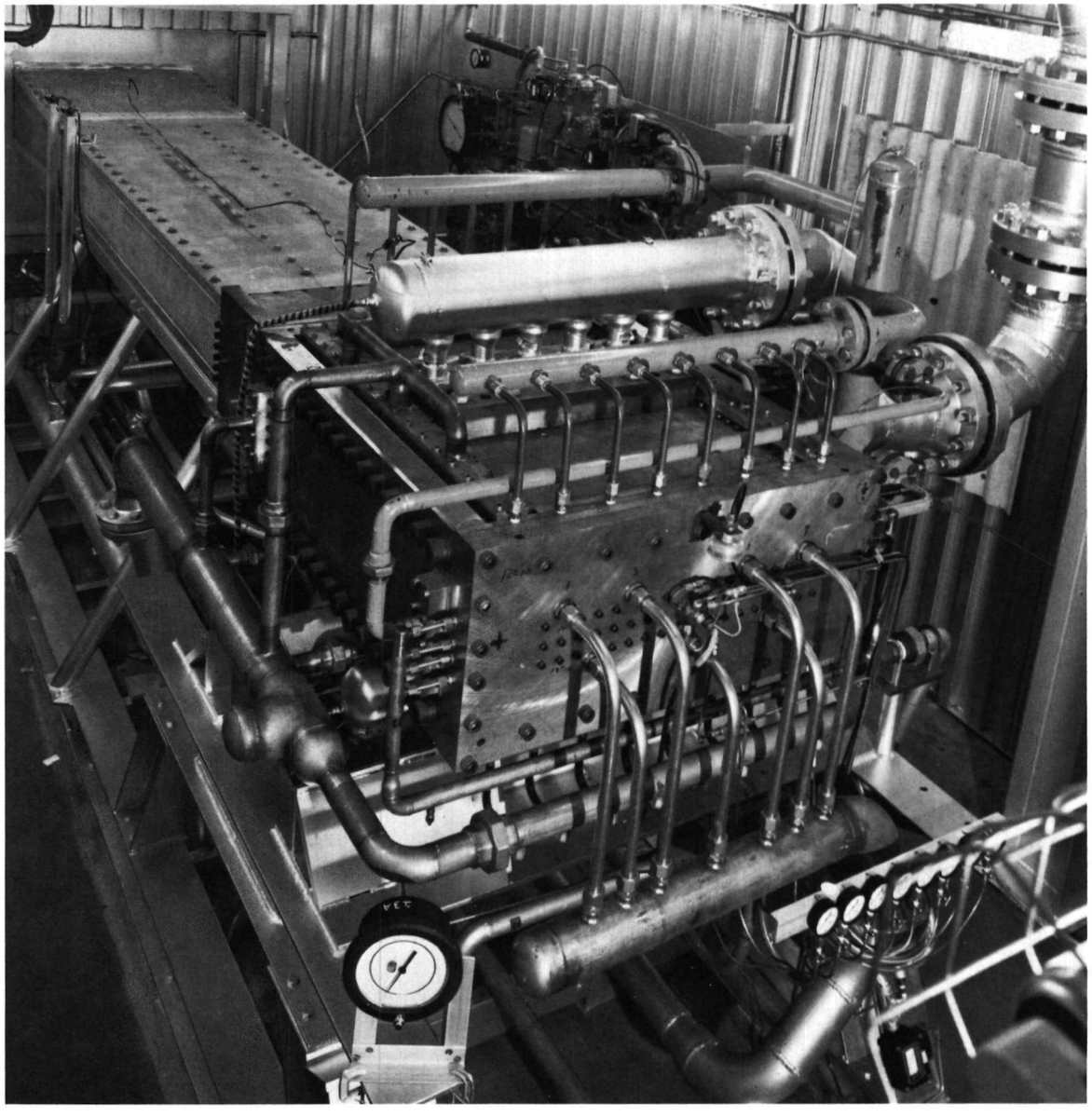
Operational since 1972

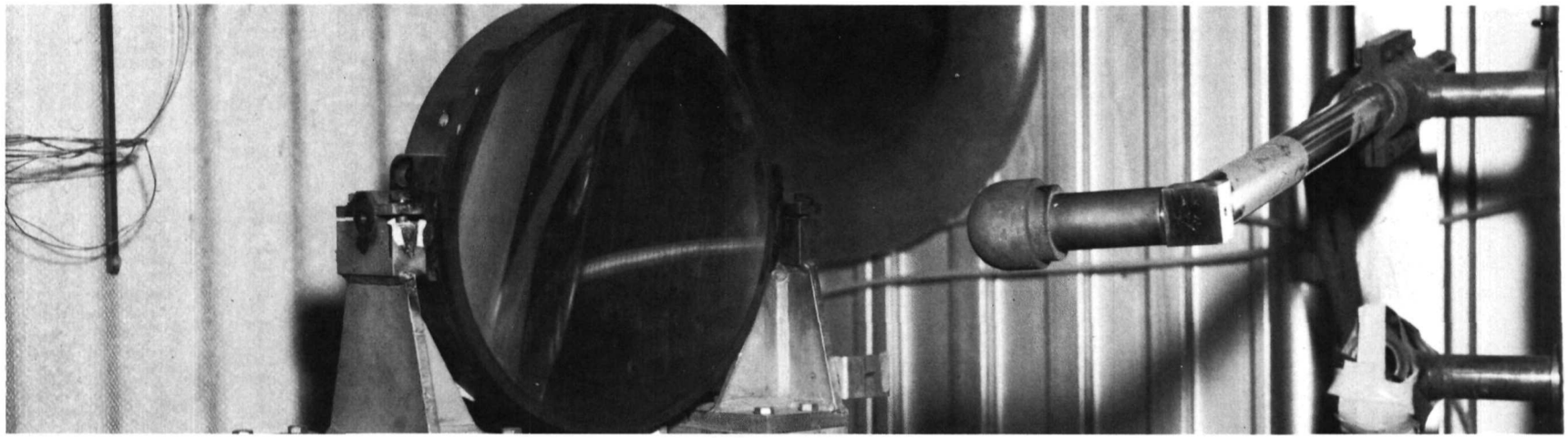
JURISDICTION:

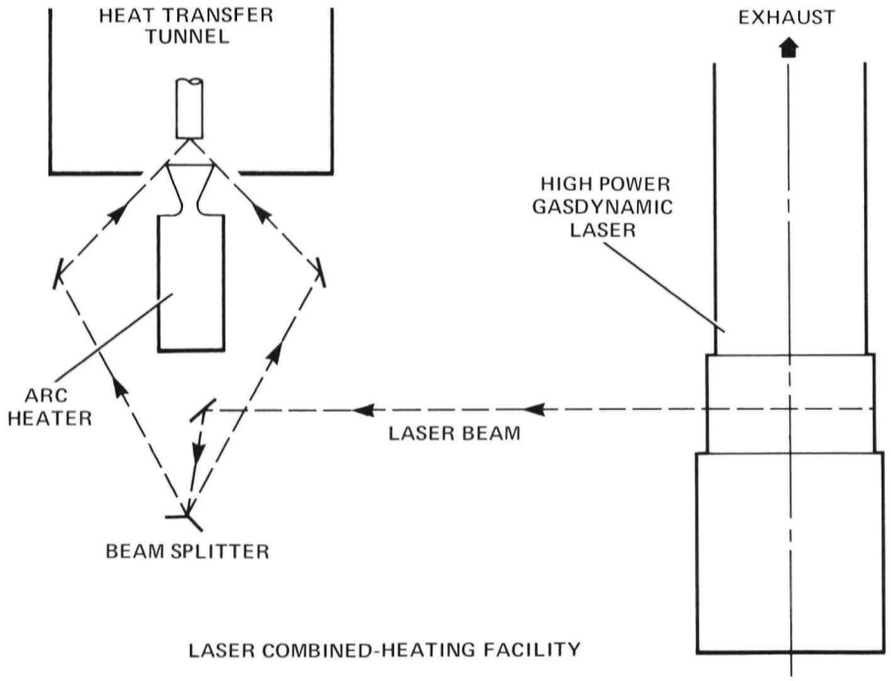
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

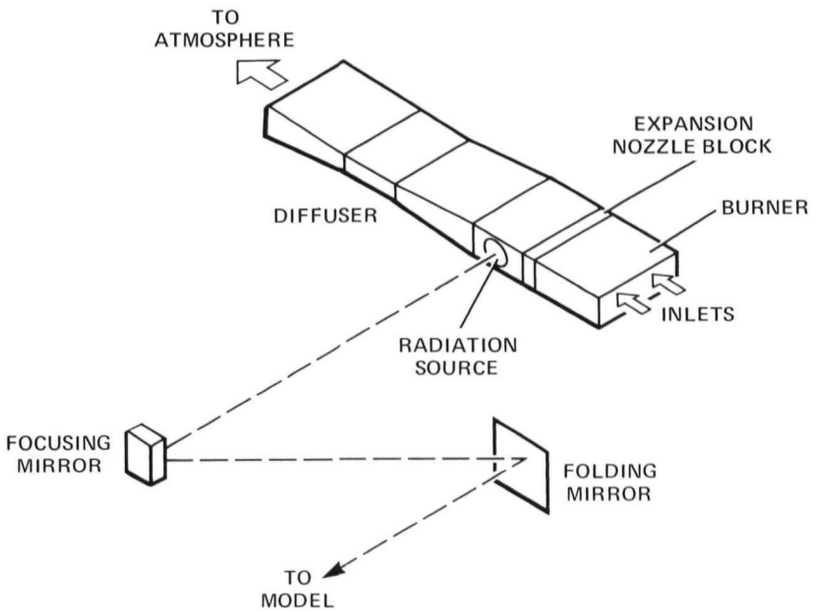
Building N-234







LASER COMBINED-HEATING FACILITY



HIGH POWER CO_2 GASDYNAMIC LASER

4. HIGH POWER PULSED Nd: GLASS LASER

DESCRIPTION:

The High Power Pulsed Nd: Glass Laser is a high brightness source of coherent radiation at 1.06 μm wavelength. This radiation is emitted in a short pulse every four minutes. The pulse length is determined by the oscillator being used. A mode locked oscillator delivers a pulse whose length can be chosen between 25 x 10^{-12} sec to 900 x 10^{-12} sec. The electronic Q-switch oscillator allows pulse lengths 7.5 x 10^{-9} sec to 15 x 10^{-9} sec. A rotary prism switch oscillator gives 35 nsec pulses. The peak energy of the pulse depends upon which oscillator is used; it varies between 10 joules to 60 joules for various pulse widths. Peak power is 10^{10} watts which can be focused onto a target to give approximately 10^{15} watts/cm^2. Such intensities lead to interesting non-linear optical and heating effects. Current use is directed toward high temperature plasma production and X-ray laser development.

PERFORMANCE:

Power	10^{10} watts, maximum
Intensity	10^{15} watts/cm^2, maximum
Wavelength	1.06 μm
Pulse Length	2.5 x 10^{-11} sec to 3.5 x 10^{-8} sec
Duty Cycle	0.25 min^{-1}

STATUS:

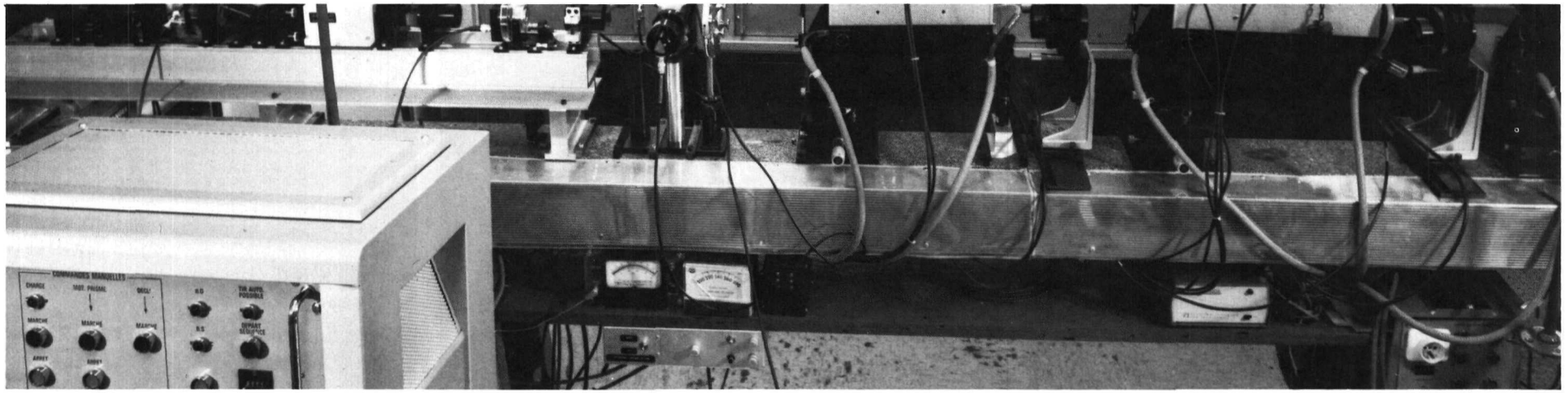
Operational; Development of short pulse oscillator continuing.

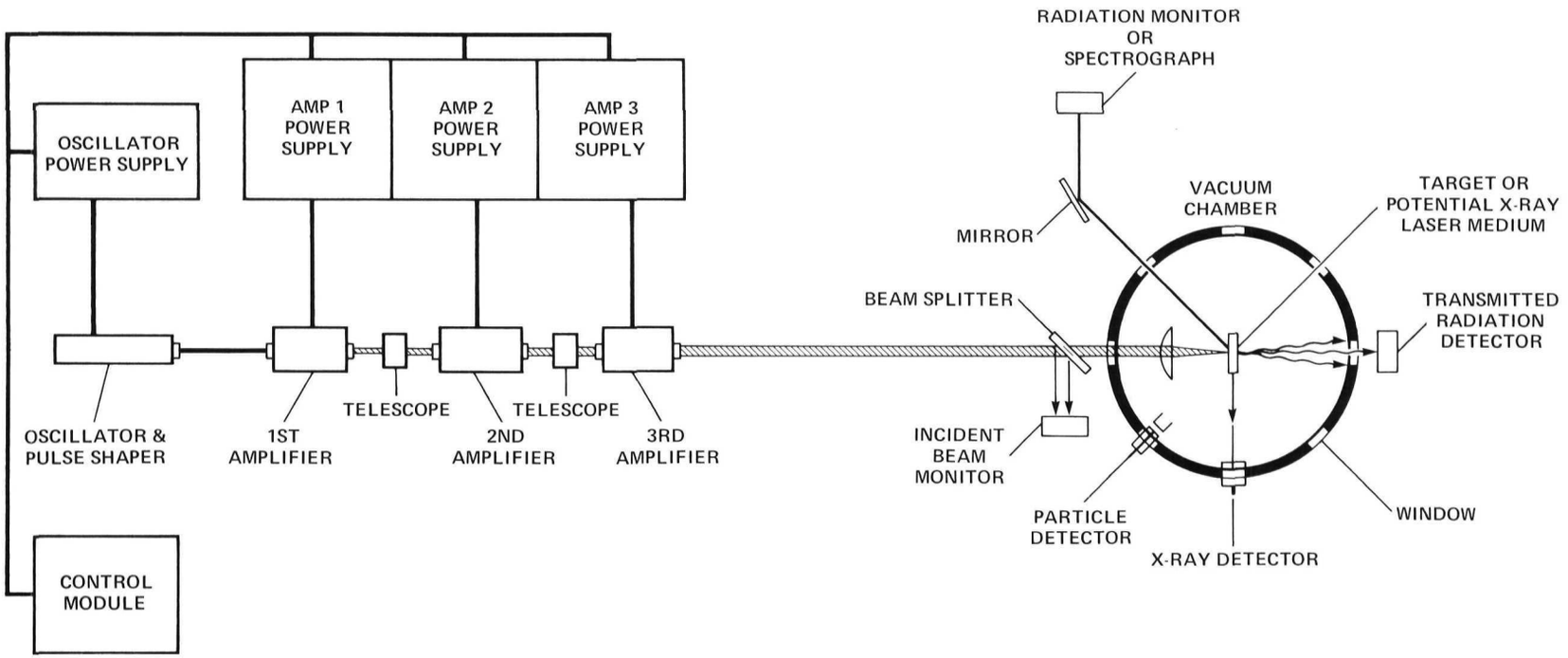
JURISDICTION:

Thermo- and Gas-Dynamics Division
Physical Gas-Dynamics and Lasers Branch
Kenneth W. Billman

LOCATION:

Building N-230




OSCILLATOR POWER SUPPLY
AMP 1 POWER SUPPLY
AMP 2 POWER SUPPLY
AMP 3 POWER SUPPLY
CONTROL MODULE
OSCILLATOR & PULSE SHAPER
1ST AMPLIFIER
TELESCOPE
2ND AMPLIFIER
TELESCOPE
3RD AMPLIFIER
RADIATION MONITOR OR SPECTROGRAPH
MIRROR
VACUUM CHAMBER
TARGET OR POTENTIAL X-RAY LASER MEDIUM
BEAM SPLITTER
TRANSMITTED RADIATION DETECTOR
INCIDENT BEAM MONITOR
PARTICLE DETECTOR
X-RAY DETECTOR
WINDOW

5. ADVANCED ENTRY HEATING SIMULATOR

DESCRIPTION:

The Advanced Entry Heating Simulator is used for aerodynamic-heating and thermal-protection-materials studies of vehicles entering planetary atmospheres. It consists of a3M.W. arc-heated supersonic wind tunnel employing vortex and magnetic field methods of arc stabilization, and operates in conjunction with a broad band radiative heating system which can furnish an additional 3,000 BTU/ft^2/sec. to 0.6-inch diameter models. Test gases include air and nitrogen with flow rates from 0.05 to 0.5 lbs/sec. Data are recorded on oscillographs or magnetic tapes utilizing calorimeters, pyrometers, and pressure cells. Models with specimen diameters from 0.5 to 2.0 inches can be accommodated. Run-time is five minutes maximum.

PERFORMANCE:

Stream Enthalpy	2,000 to 15,000 BTU/lb.
Mach numbers	2 to 5
Stagnation pressure	0.1 to 3.0 atmospheres
Arc Chamber pressure	1.0 to 15.0 atmospheres
Nozzle Exit pressure	0.0005 to 0.02 atmospheres
Nozzle Exit diameters	1.6 to 7 inches

STATUS:

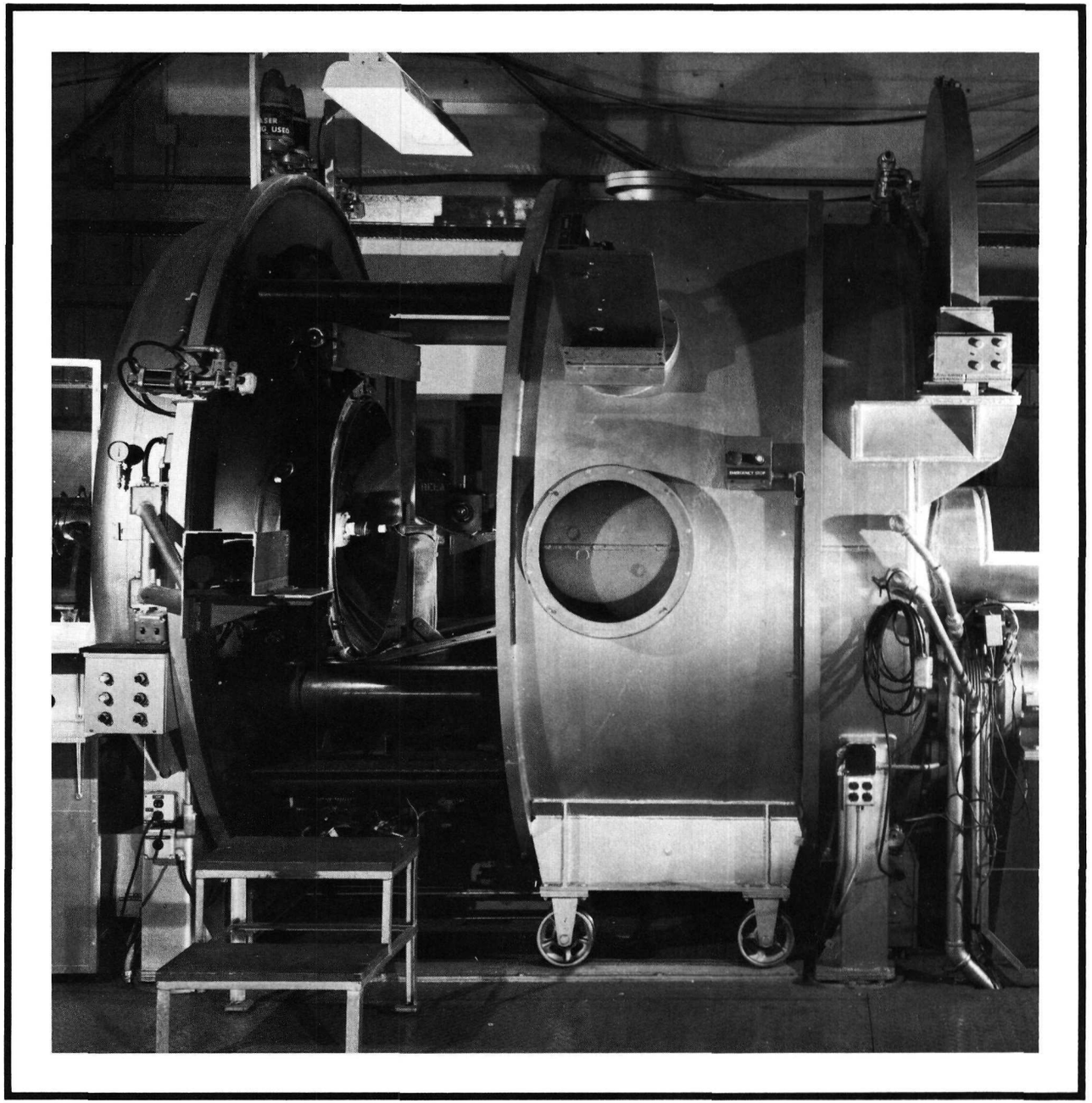
Operational since 1969

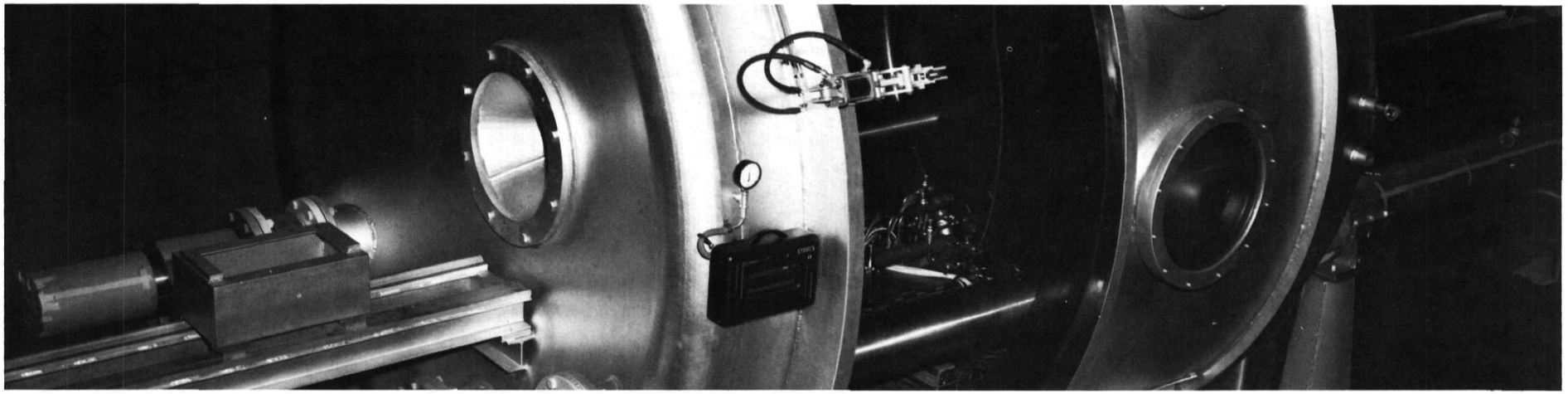
JURISDICTION:

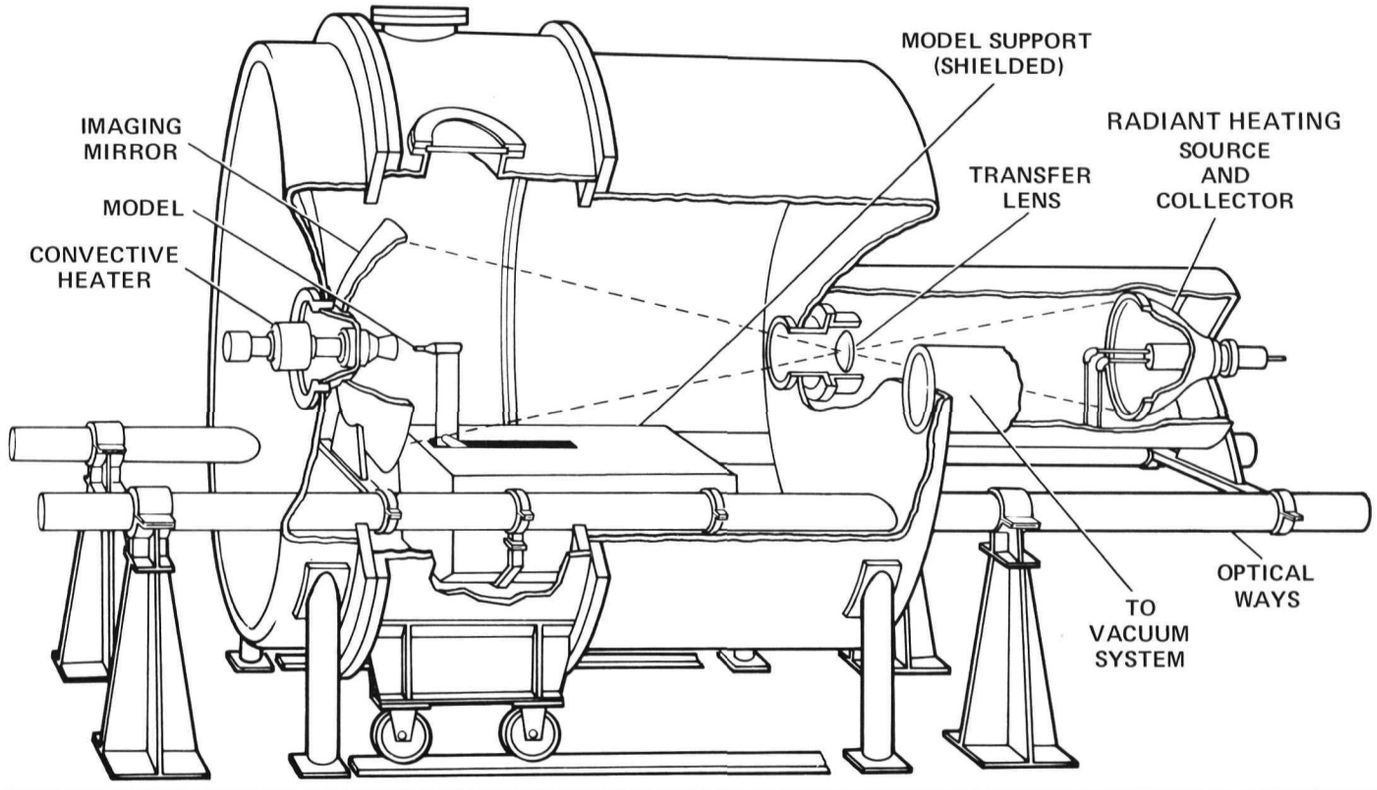
Thermo-and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-207






MODEL SUPPORT
(SHIELDED)
IMAGING
MIRROR
MODEL
CONVECTIVE
HEATER
TRANSFER
LENS
RADIANT HEATING
SOURCE
AND
COLLECTOR
OPTICAL
WAYS
TO
VACUUM
SYSTEM

6. INTERACTION HEATING FACILITY

DESCRIPTION:

The Interaction Heating Facility and the 20 Megawatt Pilot Test Facility are used for studies of aerodynamic heating in the thermal environment resulting from the interaction of a flow field with an irregular surface. Both facilities are essentially identical, except for scale and are driven by constricted arc-heaters rated at 60MW and 20MW, respectively. Power is furnished by two DC power supplies; a 40MW power supply serving building N-238, and a 20MW power supply common to building N-234. The effluent gas stream (test gas is air with flow rates from 0.1 to 5.0 lb/sec) discharges into a five-stage steam-ejector-driven vacuum system, also common to building N-234. Two nozzles are available for each facility, a conical nozzle (Mach number ~ 5), and a semi-elliptic nozzle (Mach number ~ 3). Data are recorded by digital printout paper tape and by punched paper tape from pressure cells, calorimeters, thermocouples, and optical pyrometers. Run-time is thirty minutes for each facility.

PERFORMANCE: 20MW Pilot Test Facility

Enthalpy	4,000 to 14,000 BTU/lb
Plenum pressure	1 to 10 atmospheres
Conical nozzle exit diameter (M ~ 5)	16 inches
Semi-elliptic width (M ~ 3)	15 inches, flat side

PERFORMANCE: 60MW Interaction Heating Facility

Enthalpy	4,000 to 14,000 BTU/lb
Plenum pressure	1 to 10 atmospheres
Conical nozzle exit diameter (M ~ 5)	41 inches
Semi-elliptic width (M ~ 3)	30 inches, flat side

STATUS:

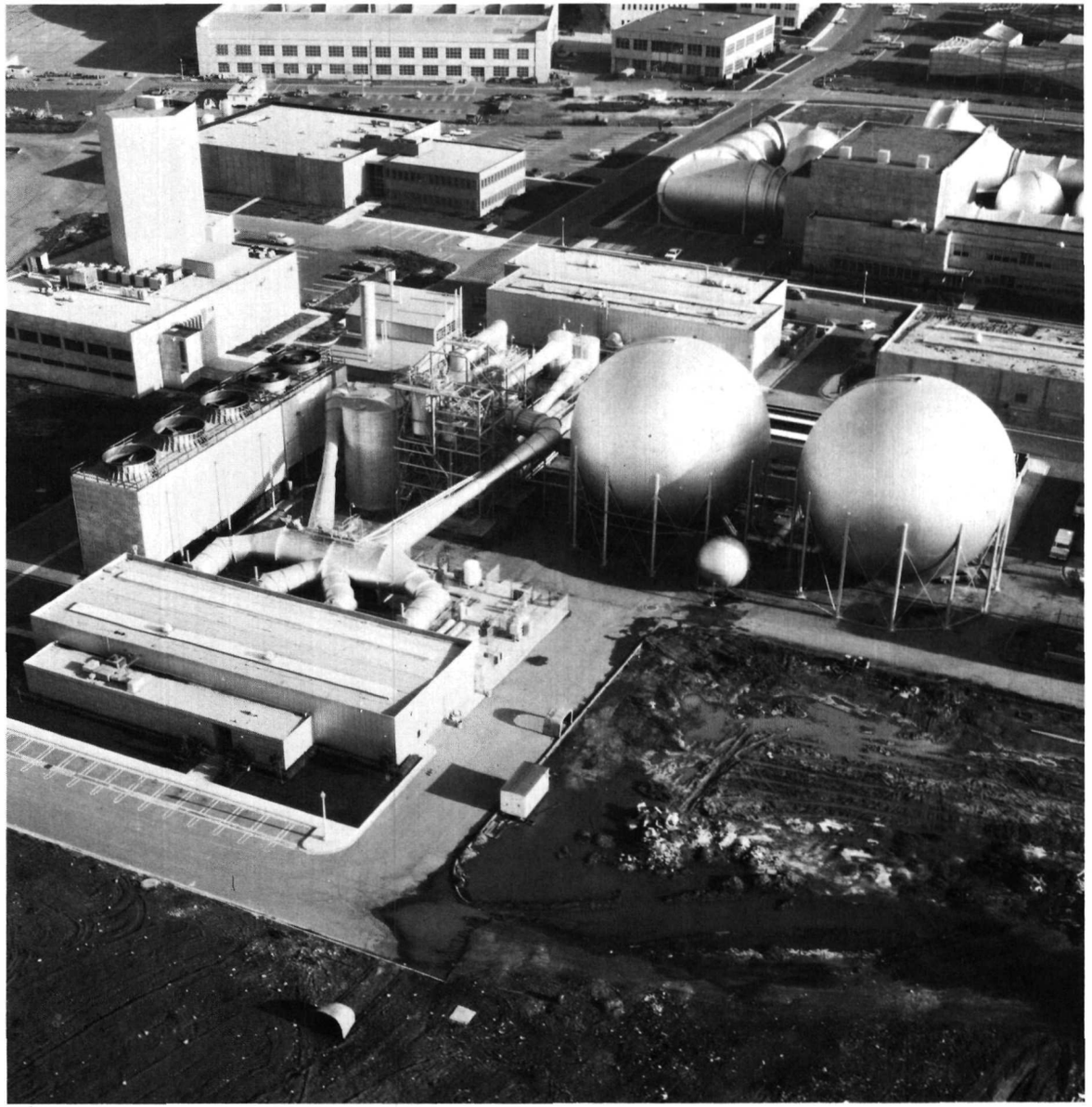
Operational since 1973 and 1974, respectively

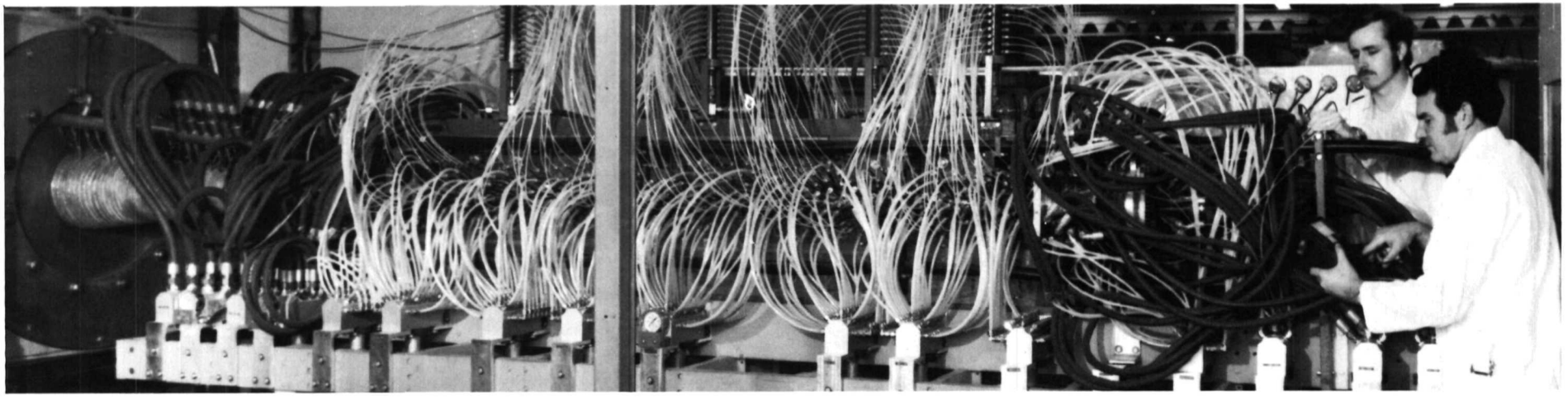
JURISDICTION:

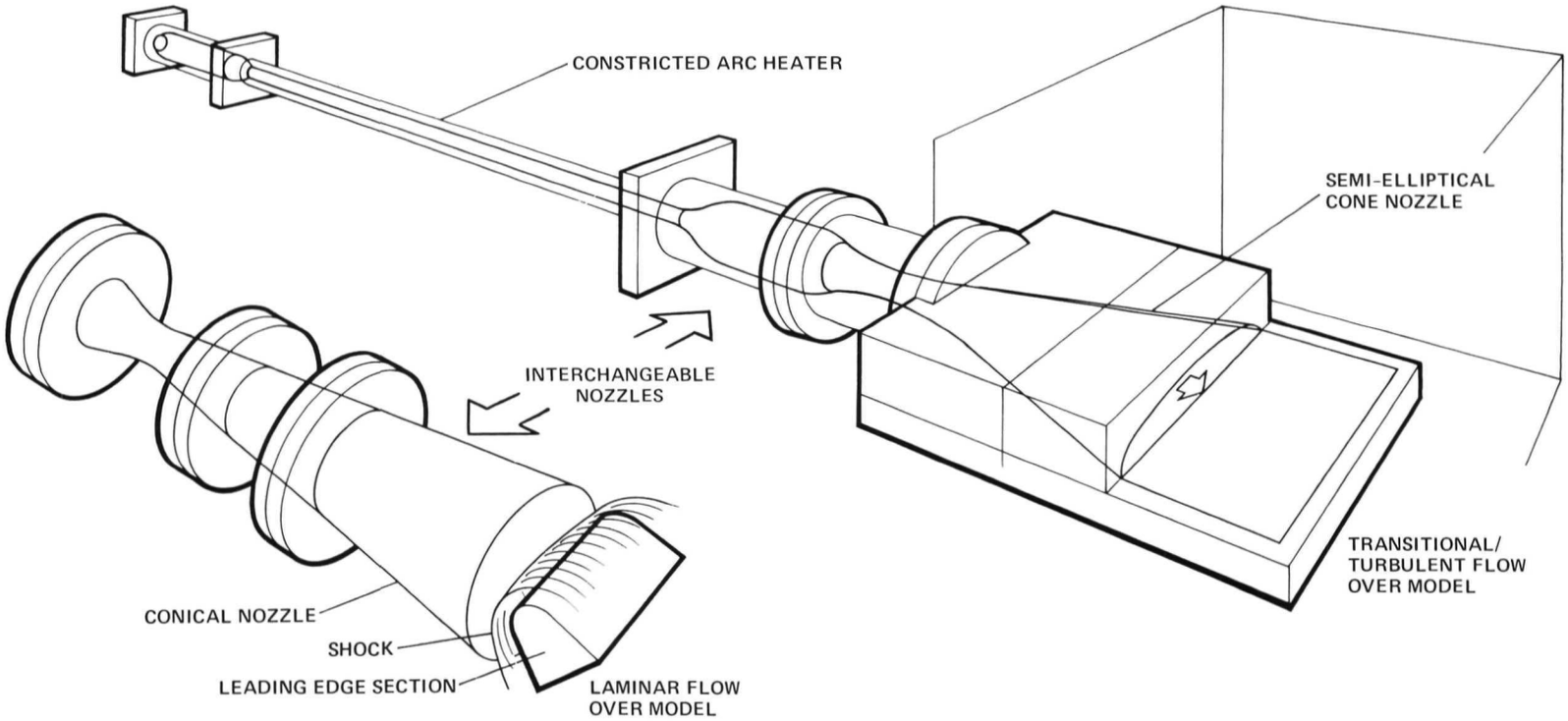
Thermo- and Gas-Dynamics Division
Thermal Protection Branch
Howard K. Larson

LOCATION:

Building N-238






CONSTRICTED ARC HEATER
SEMI-ELLIPTICAL
CONE NOZZLE
INTERCHANGEABLE
NOZZLES
TRANSITIONAL/
TURBULENT FLOW
OVER MODEL
CONICAL NOZZLE
SHOCK
LEADING EDGE SECTION
LAMINAR FLOW
OVER MODEL

7. PRESSURIZED BALLISTIC RANGE

DESCRIPTION:

The Pressurized Ballistic Range is used to measure the aerodynamic characteristics of free-flight bodies and wing-body combinations in quiescent air at speeds from subsonic to hypersonic (11,000 ft/sec, max.) and at Reynolds numbers large enough to approach those of full-scale flight. Models up to 57 mm in diameter and weighing 170 grams maximum can be accommodated. Flights are recorded utilizing a 24-station, conical-projection shadowgraph system. Conventional numerical analysis of time-distance-attitude records is then performed to obtain aerodynamic force and moment coefficient. The range test section is large enough to accommodate diverse special equipment such as cameras, long troughs for catching aerodynamically decelerated models with minimum damage, and calorimeters for measuring the total heat input into similarly decelerated models.

PERFORMANCE:

Air pressure	0.10 to 5.0 atmospheres
Air temperature	75°F
Reynolds number	300 x 10^6/ft, maximum
Model speed	3.3 km/sec, maximum
Model launching acceleration	10^6g, maximum

DIMENSIONS: Test Section

Length	203 feet
Pressure Vessel diameter	10.0 feet

STATUS:

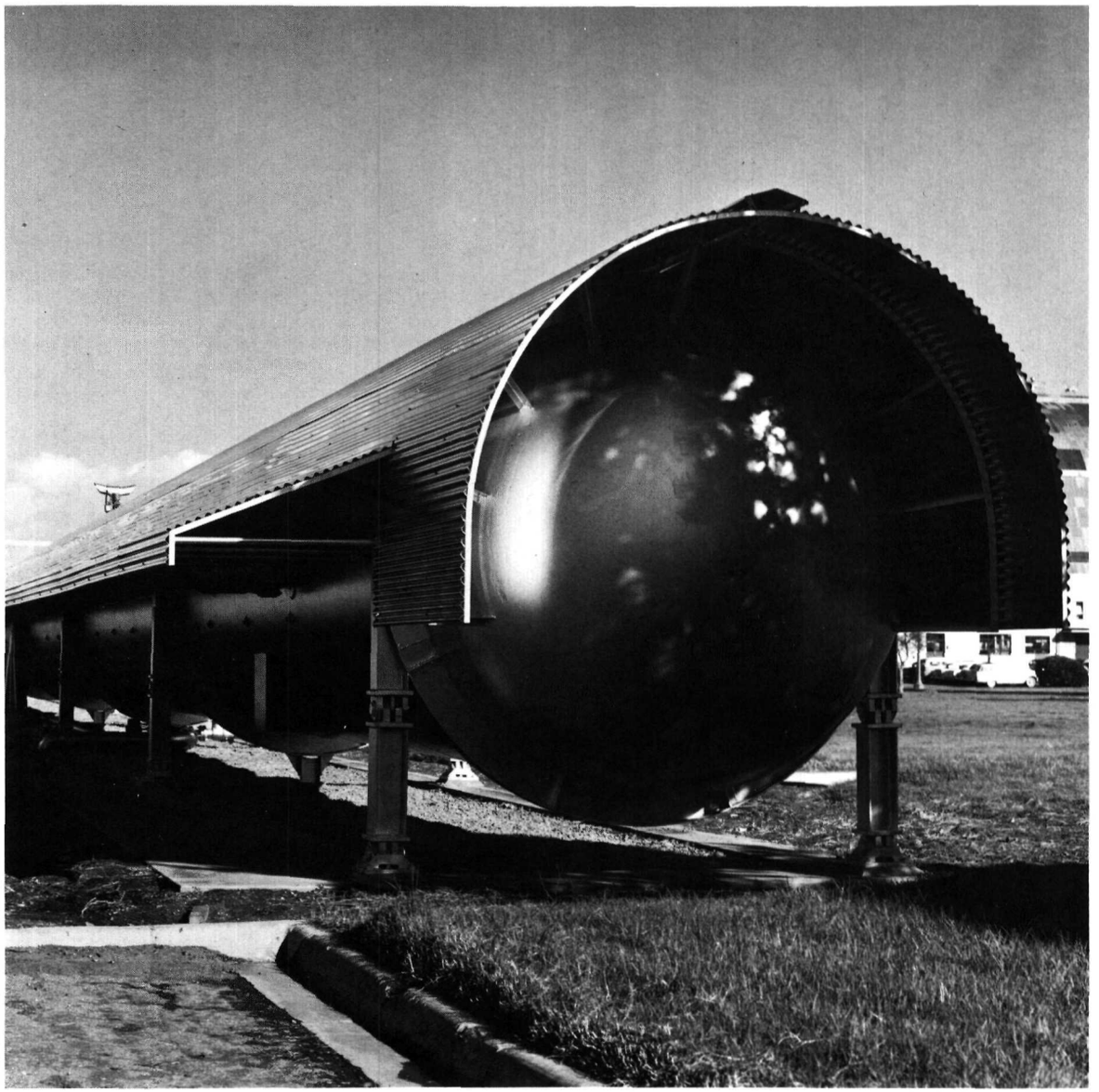
Operational since 1958

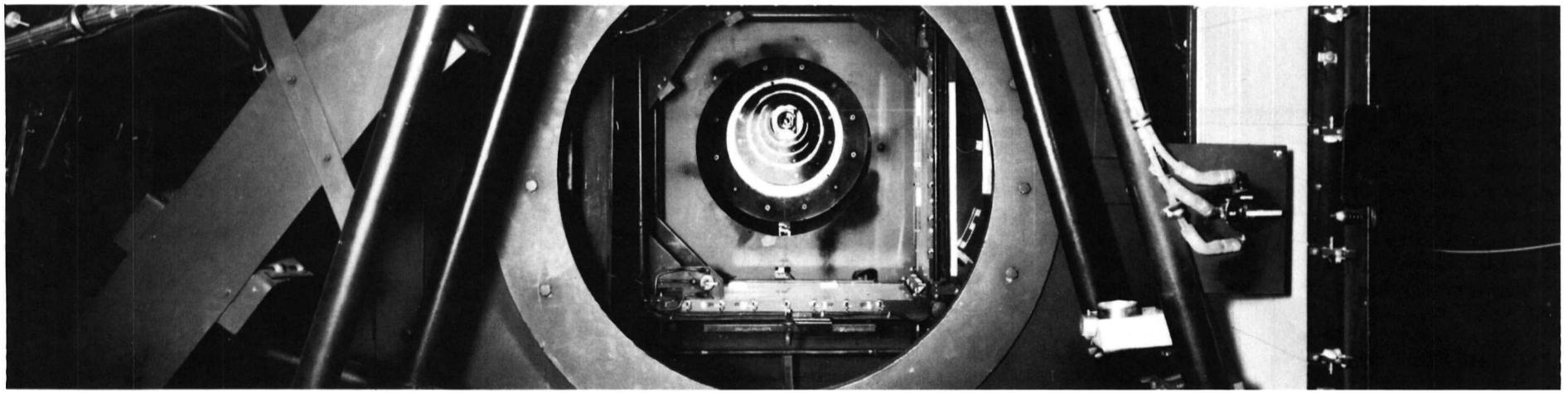
JURISDICTION:

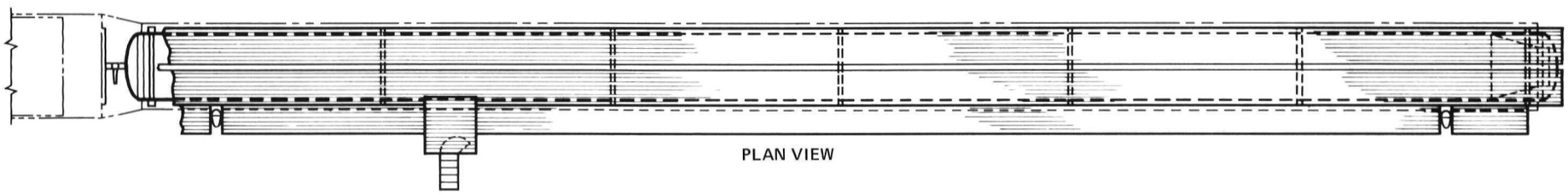
Flight Project Development Division
Systems Development Branch
Thomas N. Canning

LOCATION:

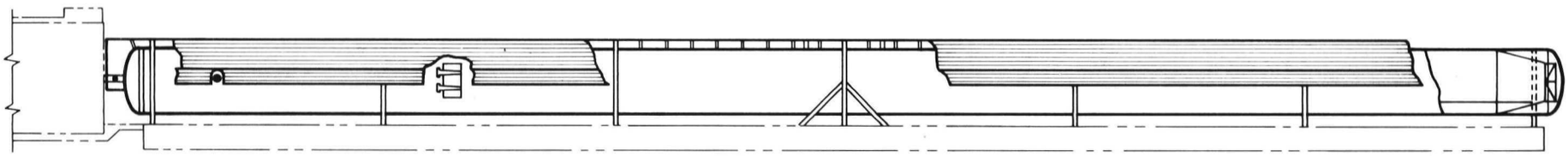
Building N-209







PLAN VIEW



ELEVATION VIEW

8. HYPERSONIC FREE-FLIGHT AERODYNAMIC FACILITY

DESCRIPTION:

The Hypersonic Free-Flight Aerodynamic Facility is used for research on gas dynamic problems of atmospheric entry. High relative speeds are achieved by launching models (in sabots if necessary) from high-speed guns into a countercurrent hypersonic air stream (14,000 ft/sec) driven by combustion-powered shock tube. Parameters derived from observations of model flights include lift, drag, static and dynamic stability, flow characteristics (including absolute spectral emissive power of shock layers and wakes), and model ablation. Models up to 37 mm in diameter and weighing 45 grams maximum can be accommodated. Shadowgraphs can be obtained at sixteen stations spaced every five feet along the test section.

PERFORMANCE:

Stream Mach Number	7.0
Stream Enthalpy	4,000 BTU/lb., maximum
Reynolds number	80×10^6 per ft., maximum
Stream static pressure	0.005 to 0.2 atmospheres
Model speed	30,000 ft/sec maximum
Model launching acceleration	1.5×10^6 g, maximum

DIMENSIONS:

Length	75.0 feet
Diameter	3.5 feet

STATUS:

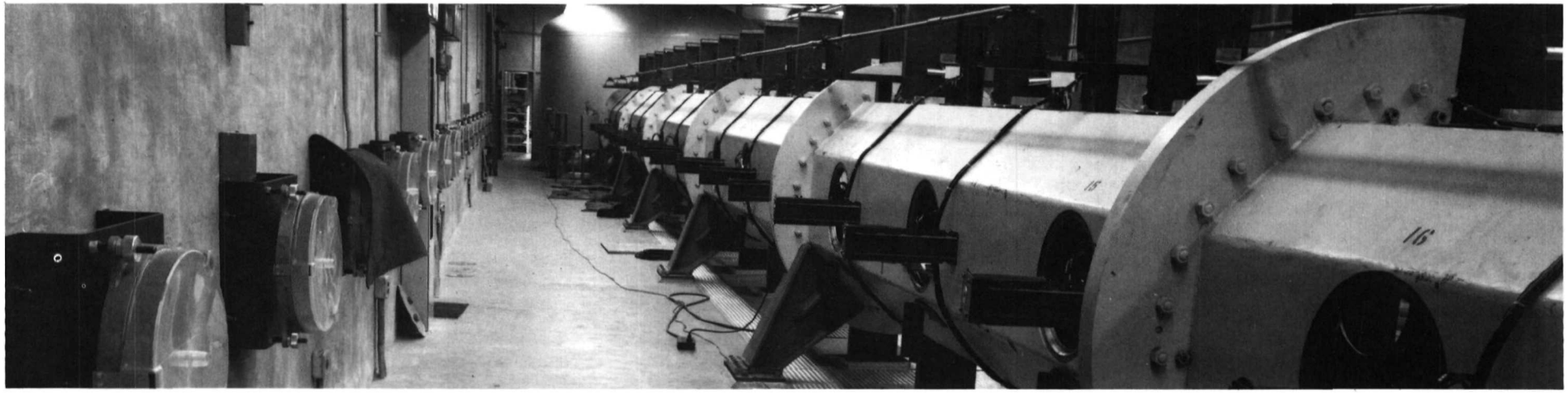
Operational since 1965

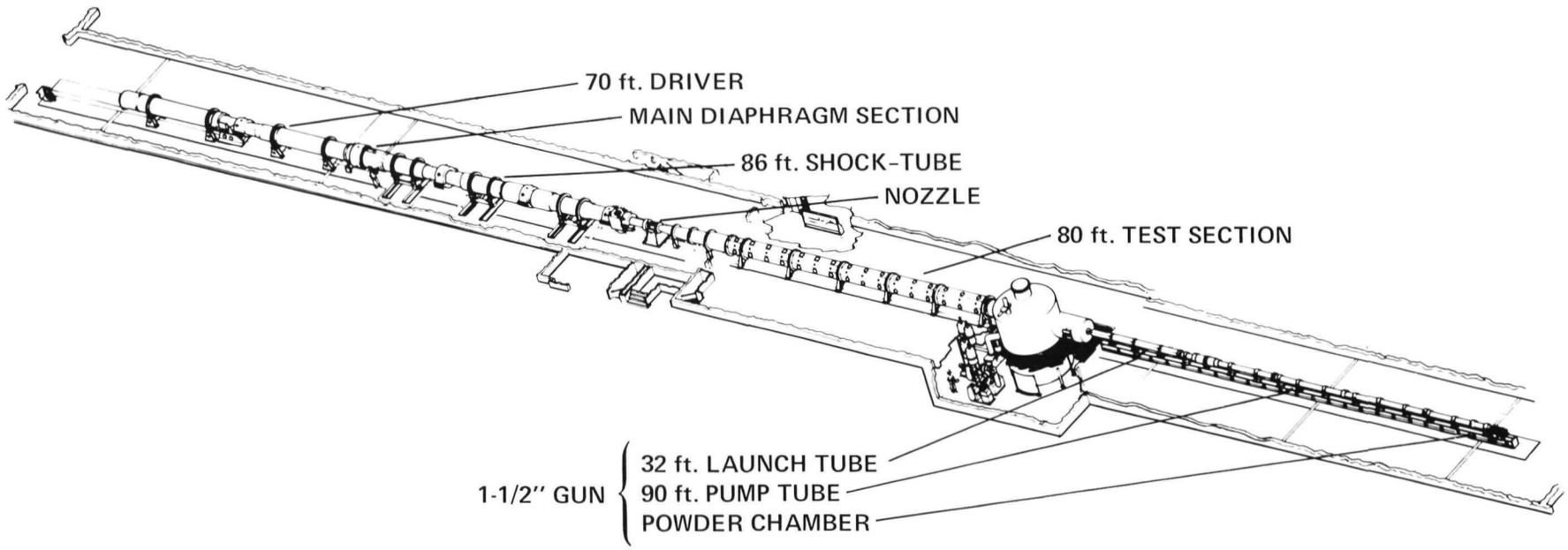
JURISDICTION:

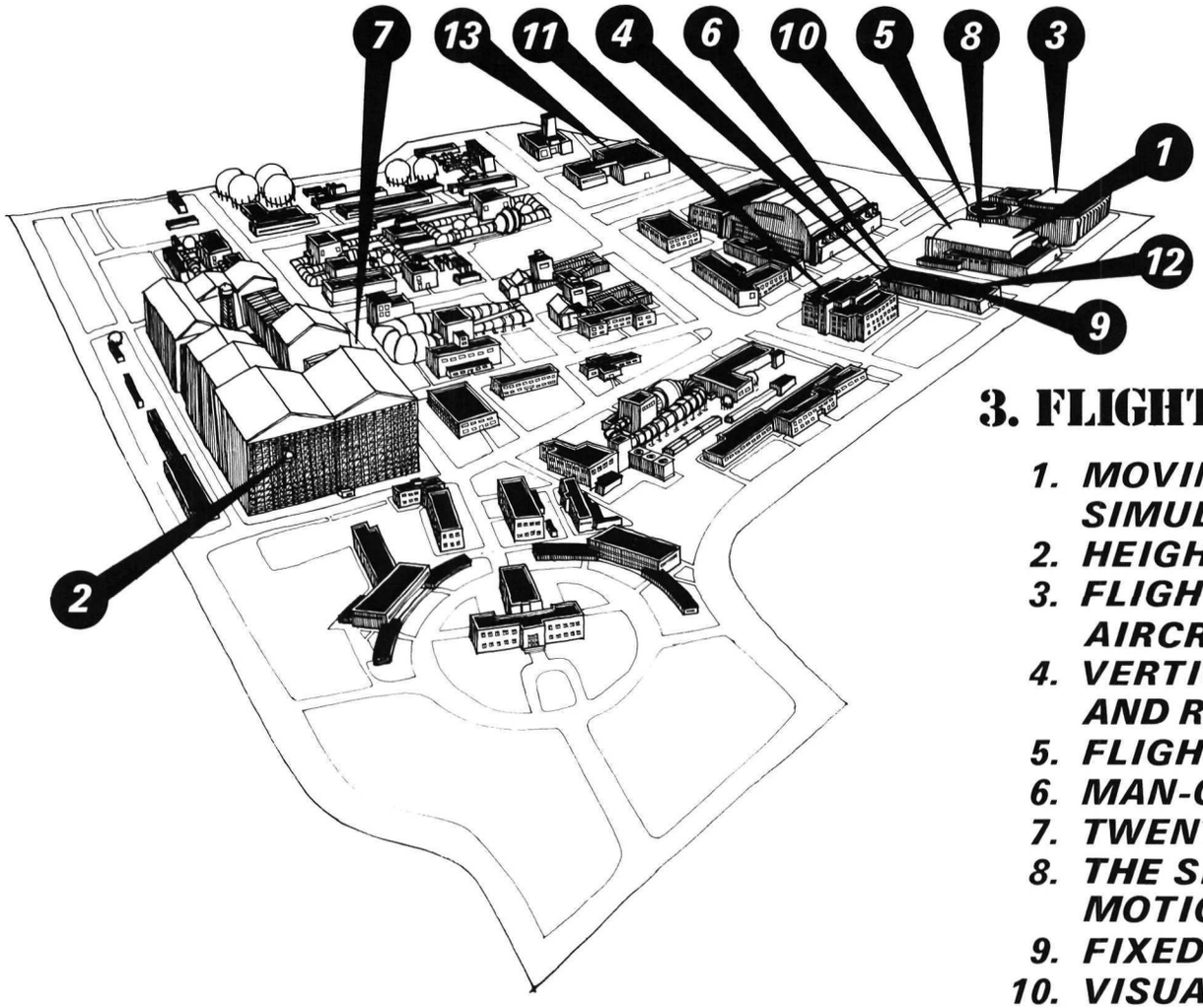
Flight Project Development Division
Systems Development Branch
Thomas N. Canning

LOCATION:

Building N-237



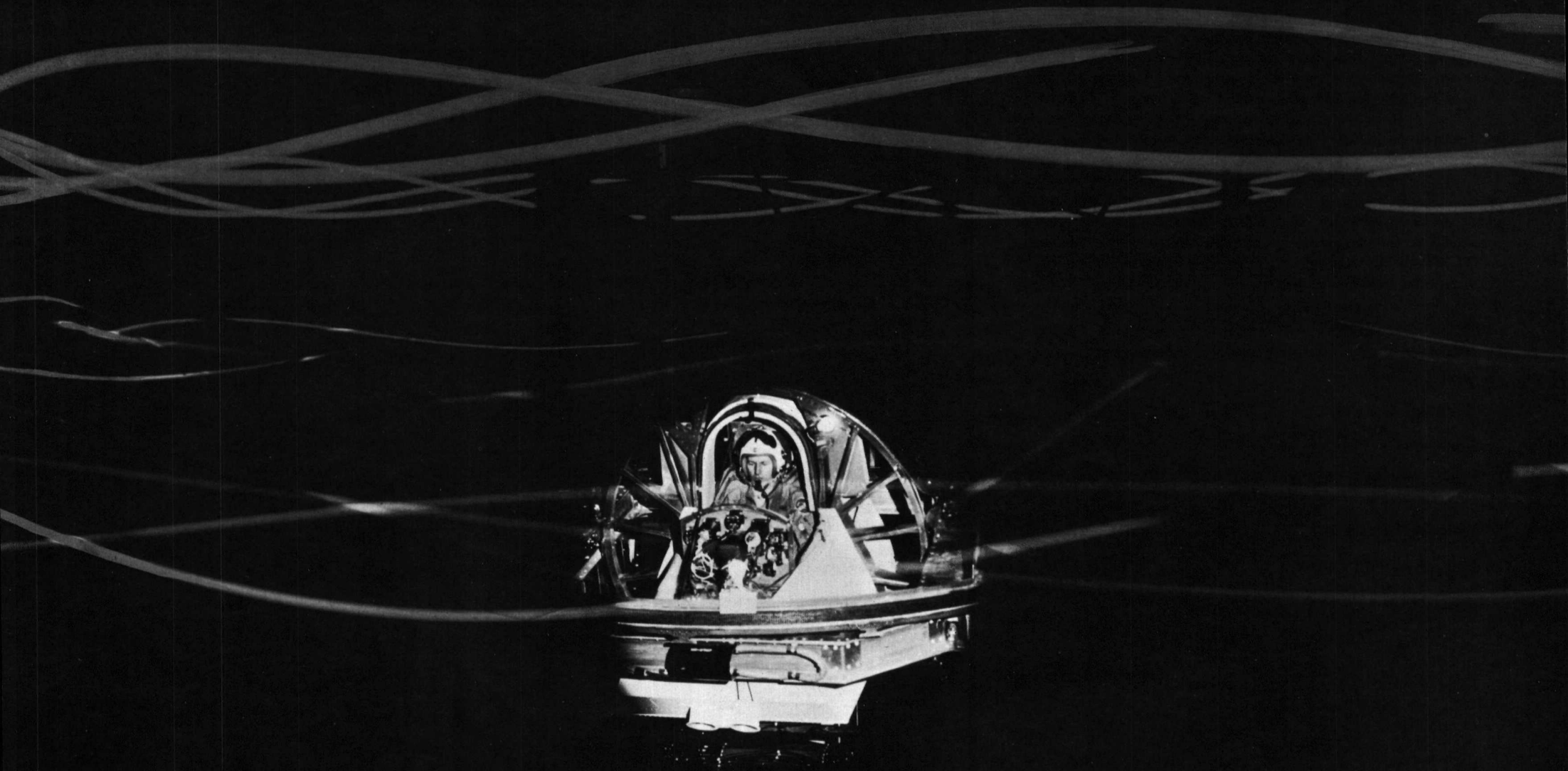

70 ft. DRIVER
MAIN DIAPHRAGM SECTION
86 ft. SHOCK-TUBE
NOZZLE
80 ft. TEST SECTION
1-1/2" GUN
32 ft. LAUNCH TUBE
90 ft. PUMP TUBE
POWDER CHAMBER



3. FLIGHT SIMULATORS

1. *MOVING-CAB TRANSPORT SIMULATOR*
2. *HEIGHT-CONTROL TEST APPARATUS*
3. *FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT*
4. *VERTICAL ACCELERATION AND ROLL DEVICE*
5. *FLIGHT AND GUIDANCE CENTRIFUGE*
6. *MAN-CARRYING ROTATION DEVICE*
7. *TWENTY-G CENTRIFUGE*
8. *THE SIX-DEGREE-OF-FREEDOM MOTION SIMULATOR*
9. *FIXED-BASE TRANSPORT SIMULATOR*
10. *VISUAL SCENE PRESENTATION SYSTEMS*
11. *COMPUTER GRAPHICS VISUAL DISPLAY SIMULATOR*
12. *ENVIRONMENTAL TEST FACILITIES*
13. *SPARCS SIMULATOR*

3. FLIGHT SIMULATORS



1. MOVING-CAB TRANSPORT SIMULATOR

DESCRIPTION:

The Moving-Cab Transport Simulator is used to evaluate a wide range of aircraft for handling qualities and control system parameters under the conditions of approach, cruise handling and taxiing. Configured as a large transport-type cab, it is equipped for side-by-side pilot/copilot operation, and is frequently used in a dual-project mode with each side outfitted as a different aircraft. The cab is provided with virtual image TV displays for each pilot; panel, center and overhead instruments; programmable hydraulic "force-feel" flight controls; auto throttles; and stereo cockpit sounds. Aircraft dynamics are provided by an EAI 8400 digital computer (32,000 word memory) and/or an EAI 231R analog computer used in the closed-loop mode.

DRIVES:

Hydraulic servo (three linear actuators operated differentially or synchronized)

STATUS:

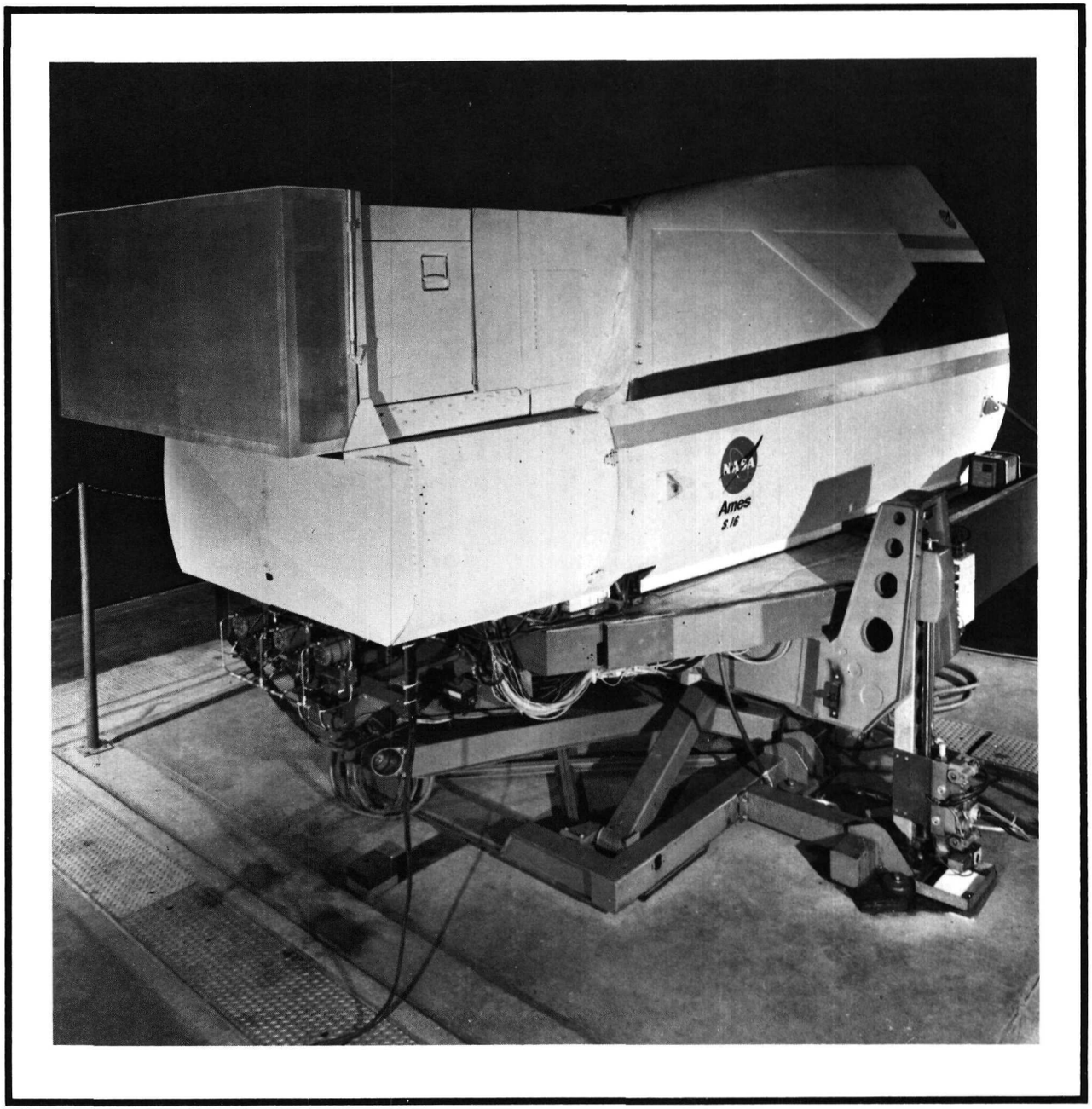
Operational since 1963

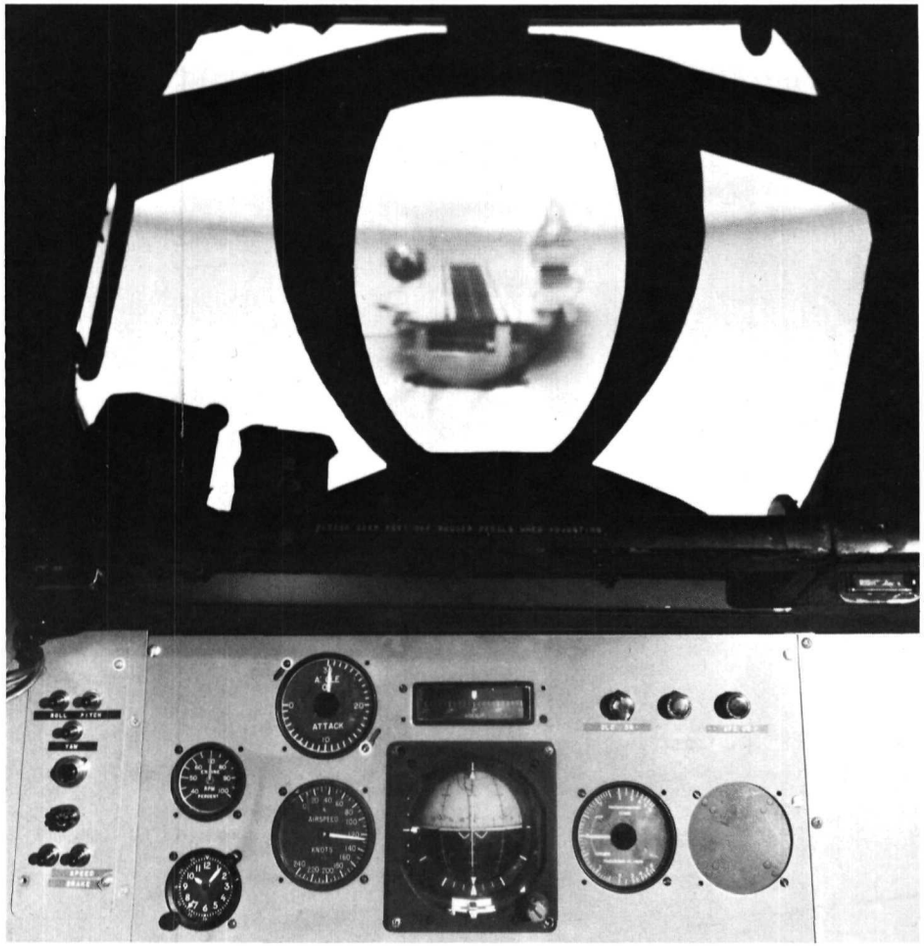
JURISDICTION:

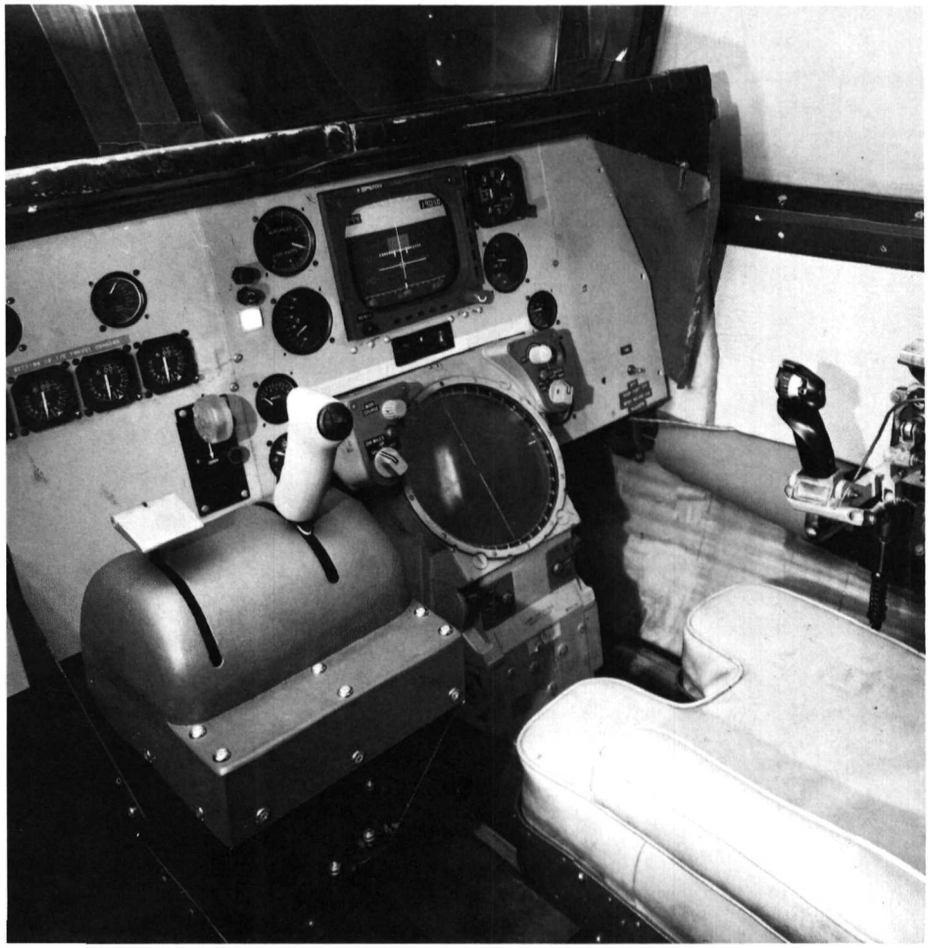
Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-210







Motions Generated	Displacement	Acceleration	Velocity	Frequency At 30° Phase Lag
Roll	±9°	4.7 Rad/sec^2	0.22 Rad/sec	0.5 Hz
Pitch	+14° −6°	4.7 Rad/sec^2	0.22 Rad/sec	0.5 Hz
Heave (Vertical)	24 in.	±1.0 g (from ambient)		0.5 Hz

2. HEIGHT-CONTROL TEST APPARATUS

DESCRIPTION:

The Height-Control Test Apparatus is used for flight simulations requiring sustained vertical acceleration or turbulence cues. The cockpit is outfitted with control wheel and rudder pedals with an adjustable force-feel system. An instrument panel is provided for a single left seat pilot. A TV monitor is provided for out-of-the-window visual displays which are generated in the Space Flight Simulation Laboratory and transmitted by direct wire cables. Aircraft dynamics are provided by an EAI 231R analog computer used in the closed-loop mode.

STATUS:

Operational since 1961

DRIVES:

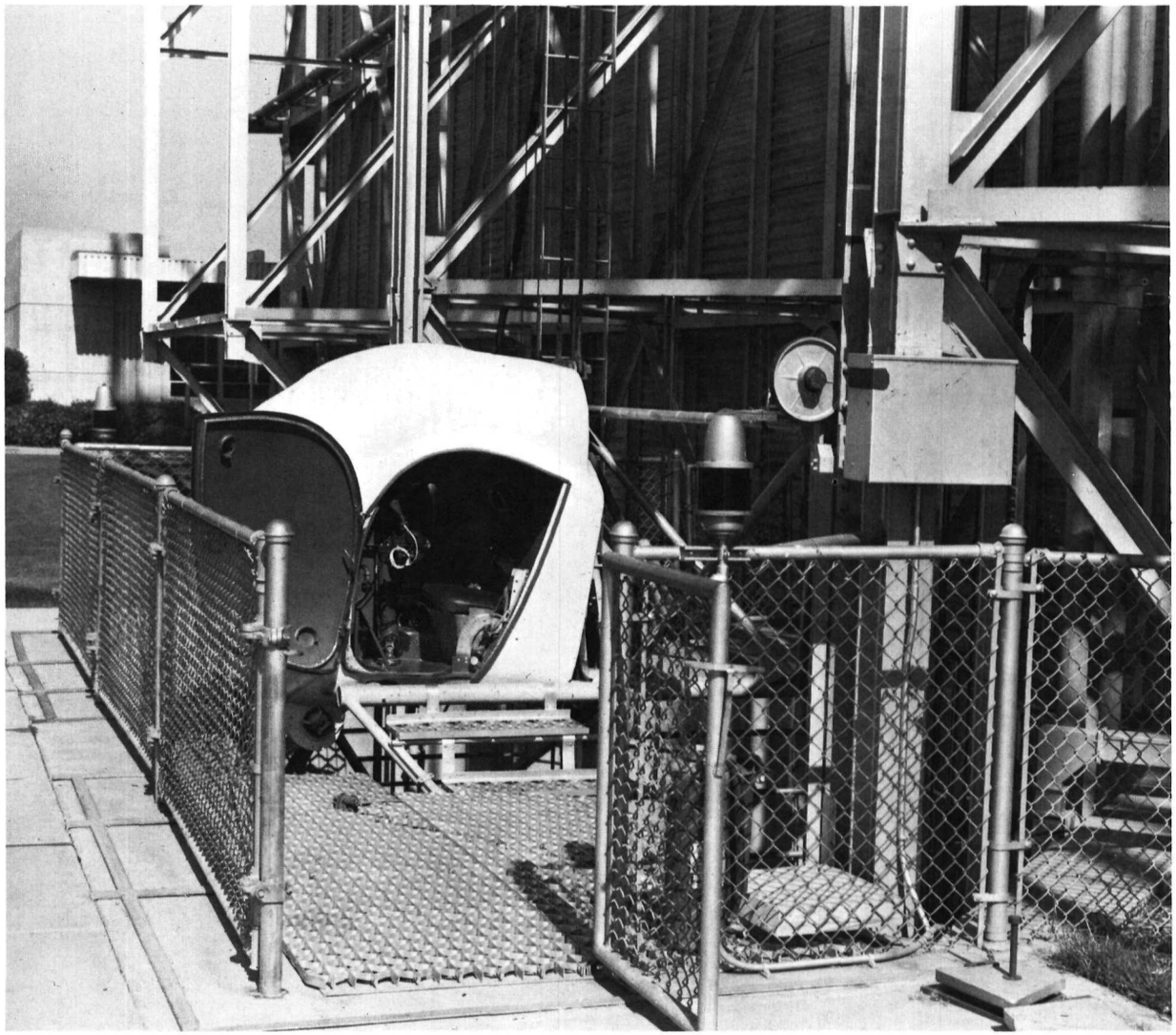
Ward-Leonard Electrical servo

JURISDICTION:

Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-221B



Motion Generated	Displacement	Acceleration	Velocity	Frequency At 30° Phase Lag
Vertical	100 ft (80 ft useable)	±0.7 g	18 ft/sec	1.5 Hz

3. FLIGHT SIMULATOR FOR ADVANCED AIRCRAFT

DESCRIPTION:

The Flight Simulator for Advanced Aircraft (FSAA) is used for investigations of landing, take-off, and general handling qualities of large aircraft as well as evaluation of crew tasks. The large lateral travel permits examination of such maneuvers as lateral side-slip during a landing approach or engine-out on take-off. Both pilot and copilot seats are available. The cab is provided with a virtual image TV display; panel, center and overhead instruments; a hydraulic control loader system; auto-throttles; and aircraft sound generator. Aircraft dynamics are provided by an XDS Sigma 8 digital computer (96,000 word memory) and an EAI 231R analog unit used in the closed-loop mode. Research operations utilizing this simulator have included investigations relating to the development of improved handling qualities and airworthiness criteria for large jets and STOL aircraft.

DRIVES:

Ward-Leonard Electric servos

STATUS:

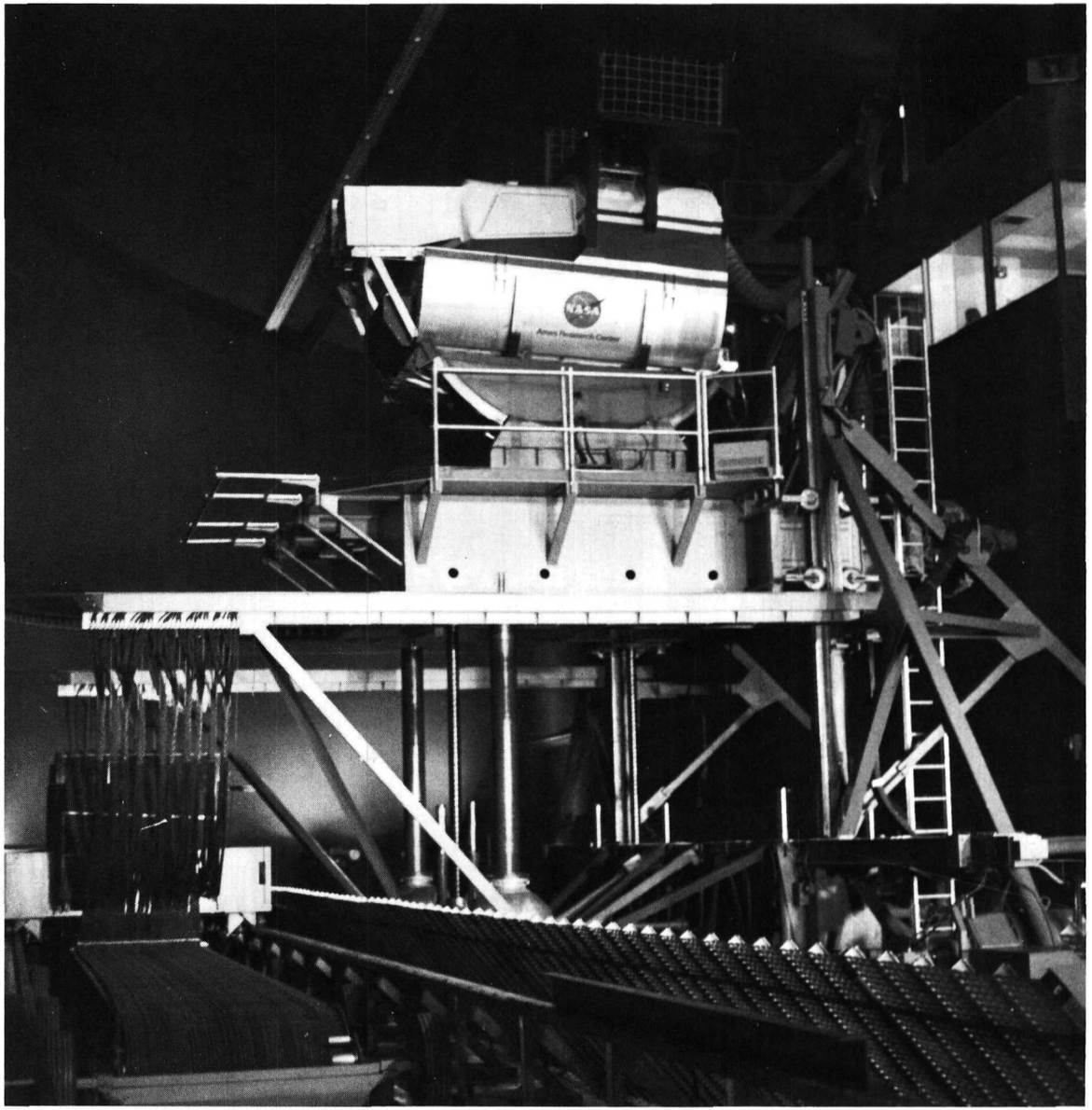
Operational since 1969

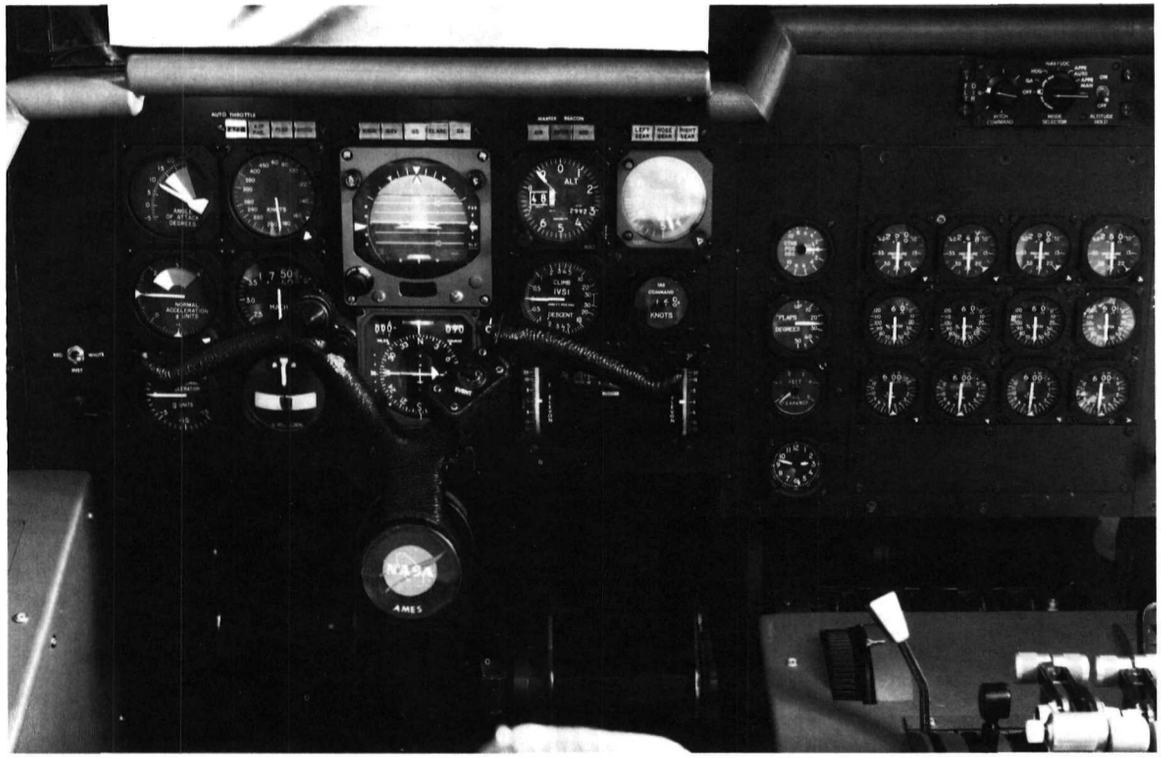
JURISDICTION:

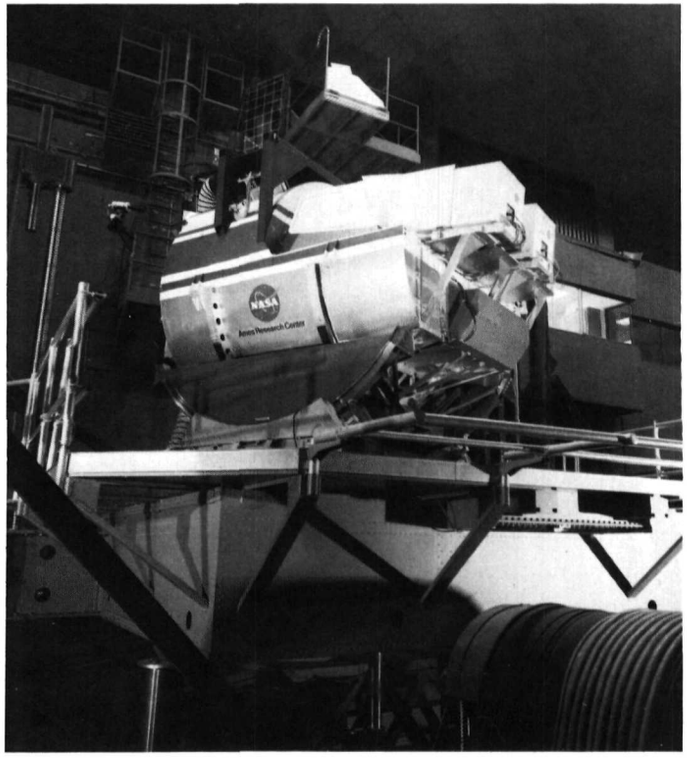
Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-243







Motions Generated	Displacement	Acceleration	Velocity	Frequency At 30° Phase Lag
Roll	±36°	1.6 Rad/sec^2	0.50 Rad/sec	3.1 Hz
Pitch	±18°	1.6 Rad/sec^2	0.50 Rad/sec	1.5 Hz
Yaw	±24°	1.6 Rad/sec^2	0.50 Rad/sec	1.7 Hz
Vertical	±4 ft	10 ft/sec^2	6.90 ft/sec	2.2 Hz
Longitudinal	±3 ft	8 ft/sec^2	5.05 ft/sec	1.8 Hz
Lateral	±40 ft	10 ft/sec^2	16.00 ft/sec	1.0 Hz

4. VERTICAL ACCELERATION AND ROLL DEVICE

DESCRIPTION:

The Vertical Acceleration and Roll Device is a dynamic flight simulator with vertical translation and roll rotation capabilities used for flight simulations requiring visual contact, as well as aircraft, spacecraft, and medical investigations requiring vertical and roll accelerations. It consists of a two-place, side-by-side cockpit supported on a vertical track. This simulator is normally operated closed-loop with flight dynamics generated on an EAI 231R analog or EAI 8400 digital computer programmed to account for vehicle dynamic response to pilot control inputs.

In the near future, a television camera will be driven closed-loop for acquiring a TV monitor view of a model runway and surrounding countryside as a visual aid in landing approach studies.

DRIVES:

Rotary hydraulic servo motors provide linear motion for the vertical excursion, controlled by an electro-hydraulic servo valve. An electrically controlled linear actuator is used for roll.

STATUS:

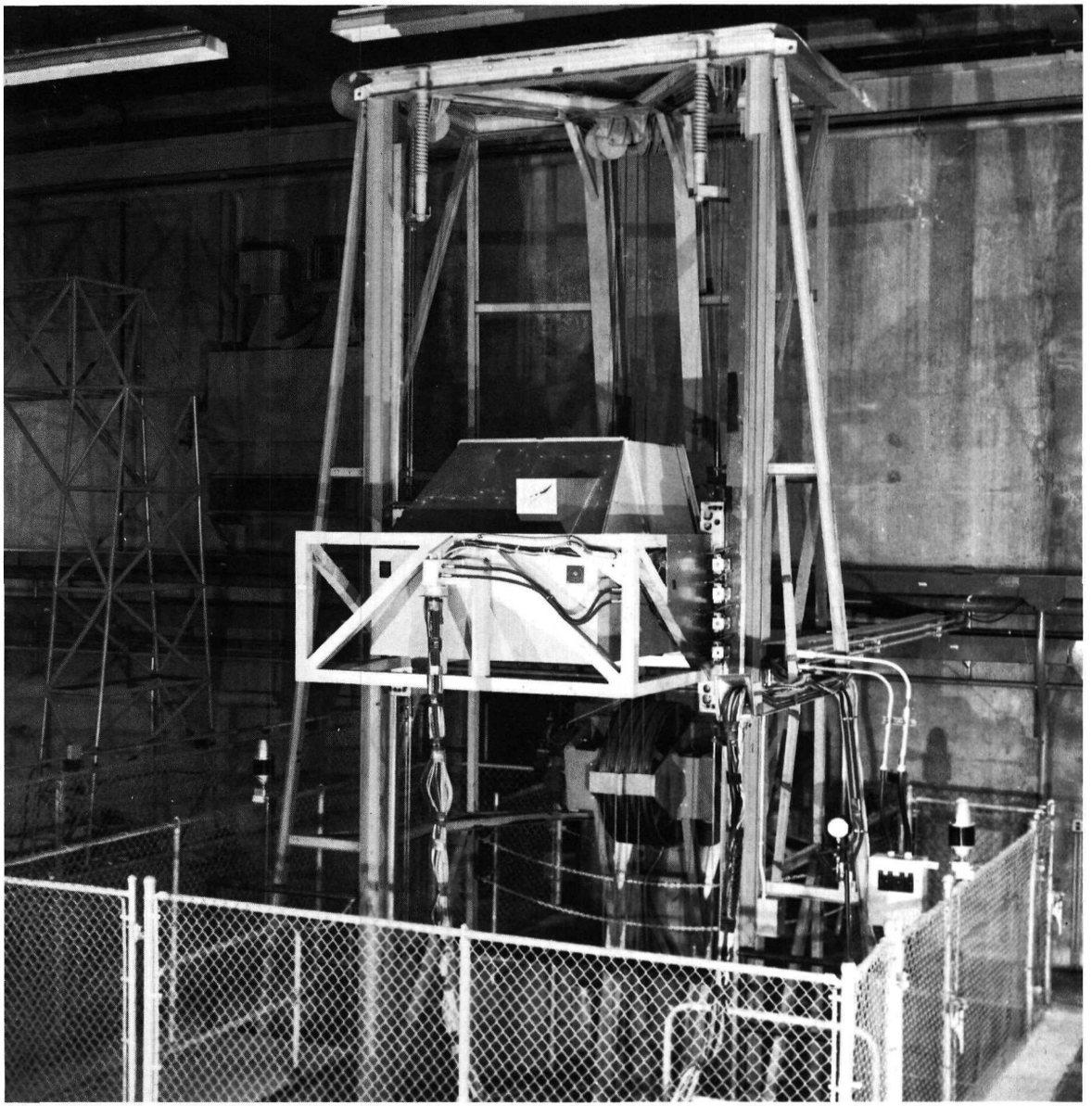
Operational since 1973

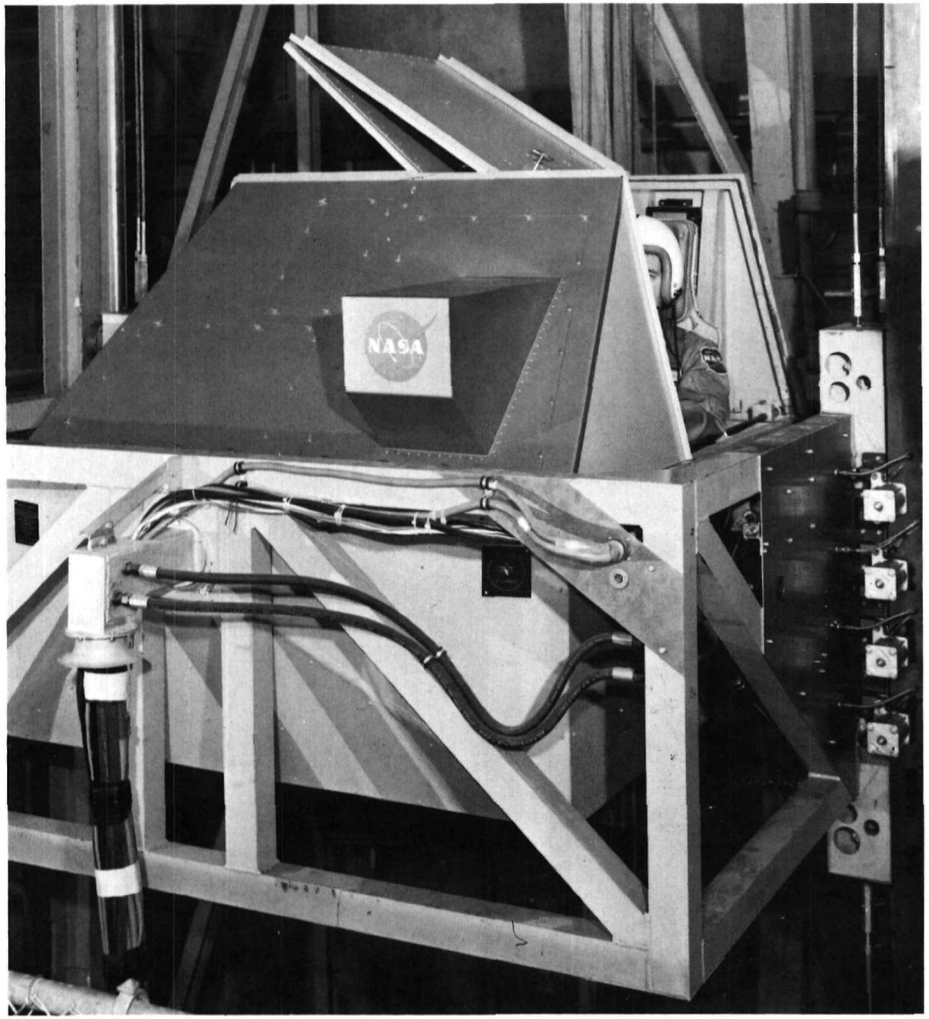
JURISDICTION:

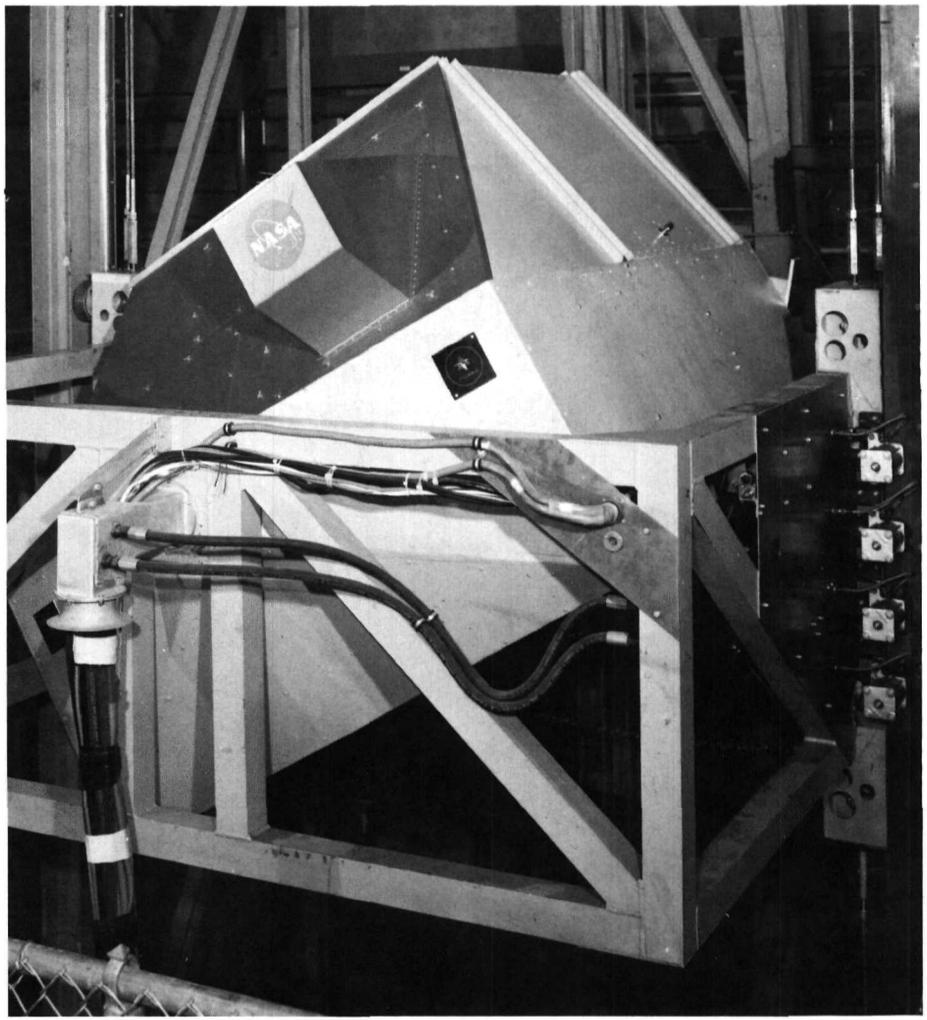
Life Sciences Directorate
Melvin Sadoff

LOCATION:

Building N-239A







Motions Generated	Displacement	Acceleration	Velocity
Vertical	±10 ft	±2 g	±12 ft/sec
Roll (not man-rated)	±30°	±3 Rad/sec^2	±3 Rad/sec

5. FLIGHT AND GUIDANCE CENTRIFUGE

DESCRIPTION:

The Flight and Guidance Centrifuge is used for spacecraft mission simulations and is adaptable to two configurations. Configuration I: The cab will accommodate a three-man crew for space mission research. The accelerations and rates are intended to be smoothly applicable at very low value so that navigation and guidance procedures using a high-accuracy, out-the-window display may be simulated. Configuration II: The simulator can use a one-man cab for human tolerance studies and performance testing. Atmosphere and temperature can be varied as stress inducements. This simulator is operated closed-loop with digital or analog computation. It is currently man-rated for 3.5g maximum.

DRIVES:

Hydraulic servos

STATUS:

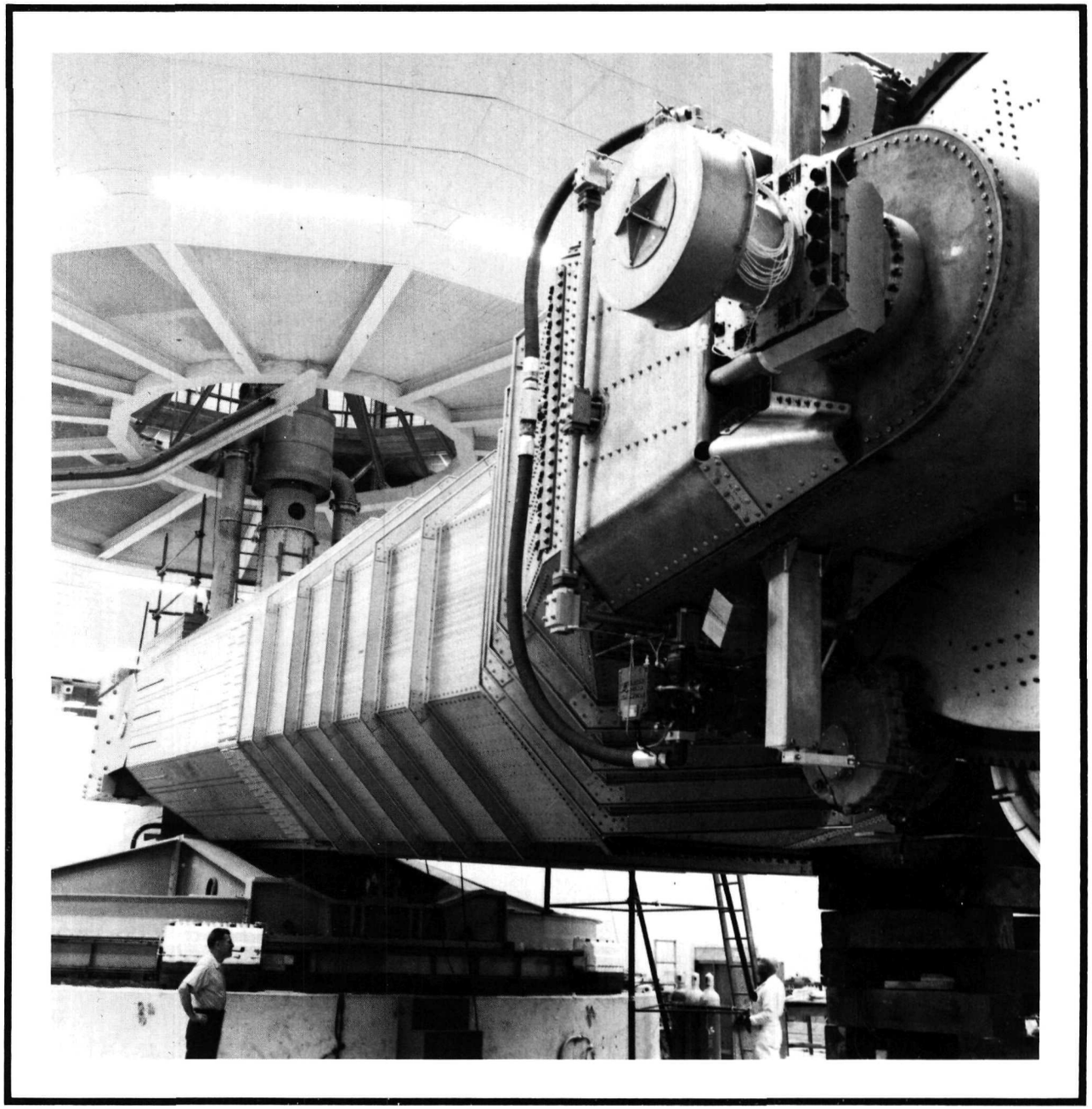
Operational since 1972

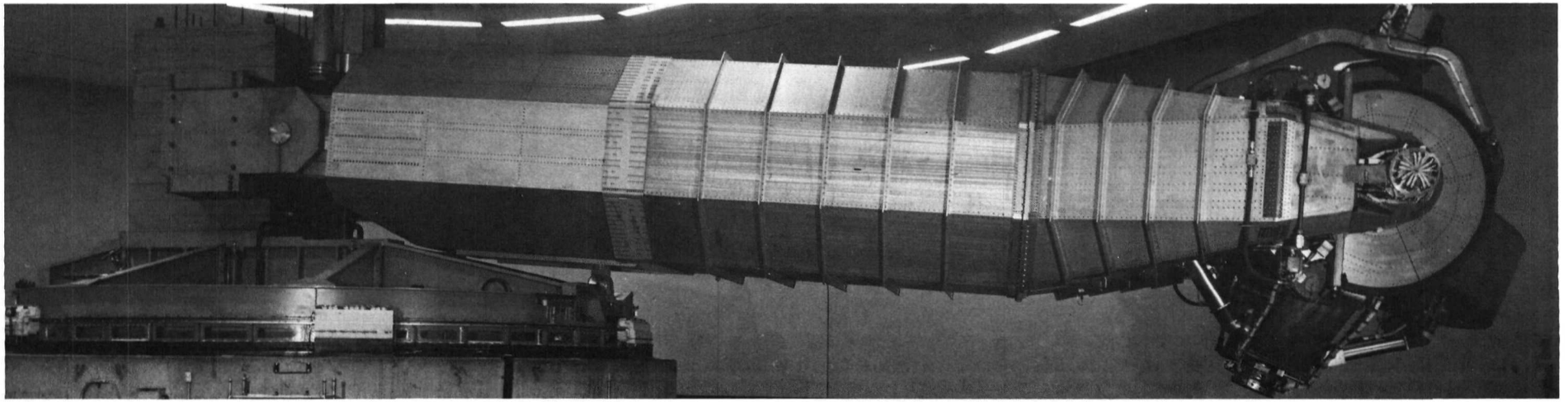
JURISDICTION:

Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-243





Motions Generated		Displacement	Acceleration	Velocity	Frequency At 30° Phase Lag
Configuration I*	Roll	Unlimited	12 Rad/sec^2	6 Rad/sec	1.75 Hz
	Pitch	Unlimited	5 Rad/sec^2	2 Rad/sec	1.75 Hz
	Yaw	Unlimited	5 Rad/sec^2	2 Rad/sec	1.75 Hz
	Arm (Radial)	Unlimited	20 g (Angular)	3.6 Rad/sec	
	(Radial Onset)		7.5 g/sec		
Configuration II*	Roll	Unlimited	18 Rad/sec^2	6 Rad/sec	3.0 Hz
	Pitch	Unlimited	6 Rad/sec^2	2 Rad/sec	3.0 Hz
	Yaw	Unlimited	6 Rad/sec^2	2 Rad/sec	3.0 Hz
	Arm (Radial)	Unlimited	50 g (Angular)	5.7 Rad/sec	
	(Radial Onset)		7.5 g/sec		

*design specifications

6. MAN-CARRYING ROTATION DEVICE

DESCRIPTION:

The Man-Carrying Rotation Device is used for determining the physiological effects on human subjects and their ability to perform various tasks when subjected to precise angular accelerations and rates for specified periods of time. The rotation may be imposed as yaw, pitch, or roll by varying the subject's orientation. The subject's head (vestibular sensors) may be located on the rotation axis or up to four feet from the axis. This device is operated closed-loop with digital or analog computation.

A hydrostatic bearing with a diameter of four feet supports the rotating components including the armature of the 20 Hp. drive motor and a separately driven slip ring assembly, employed to reduce friction. These design features allow this device to present precisely controlled angular acceleration stimuli from 0.1 to $30^{\circ}/sec^2$ with a rise time of 0.1 sec. Angular vibration varies from $0.02^{\circ}/sec^2$ at low rates of rotation to $0.1^{\circ}/sec^2$ at 10 rpm.

DRIVES:

Electrical servo

STATUS:

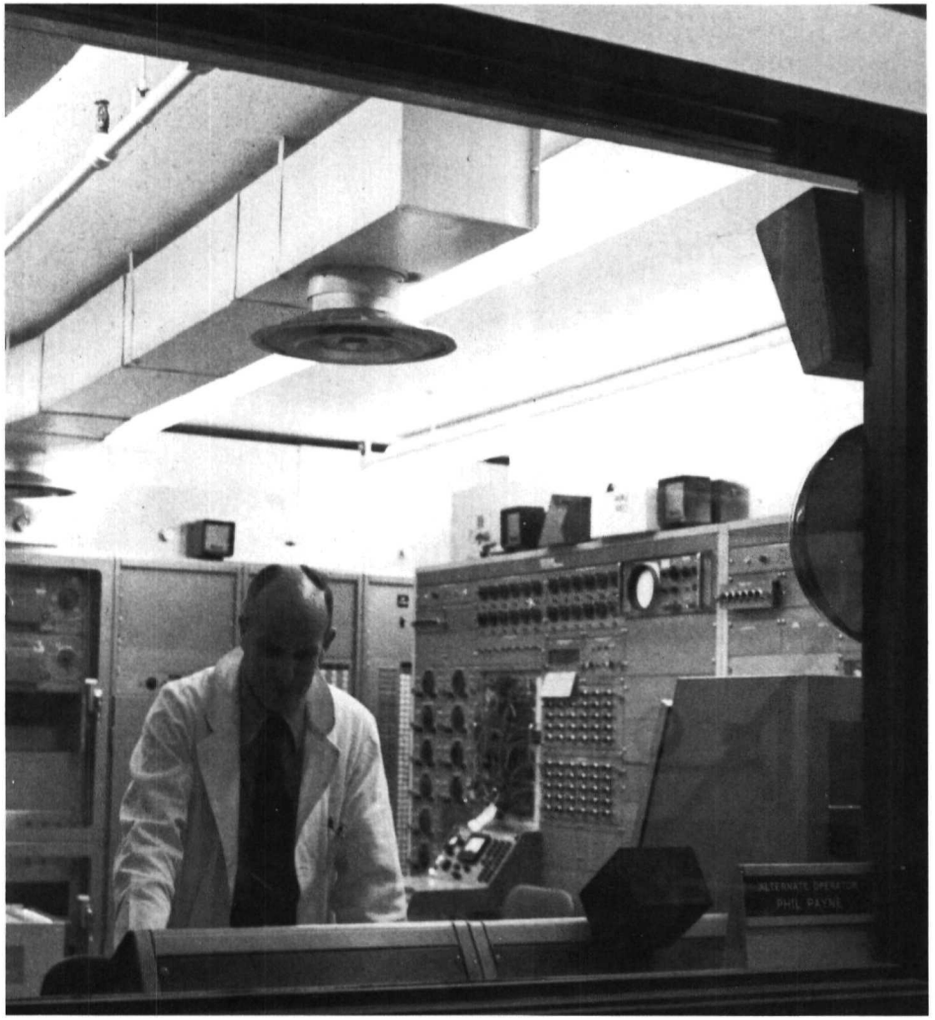
Operational since 1966

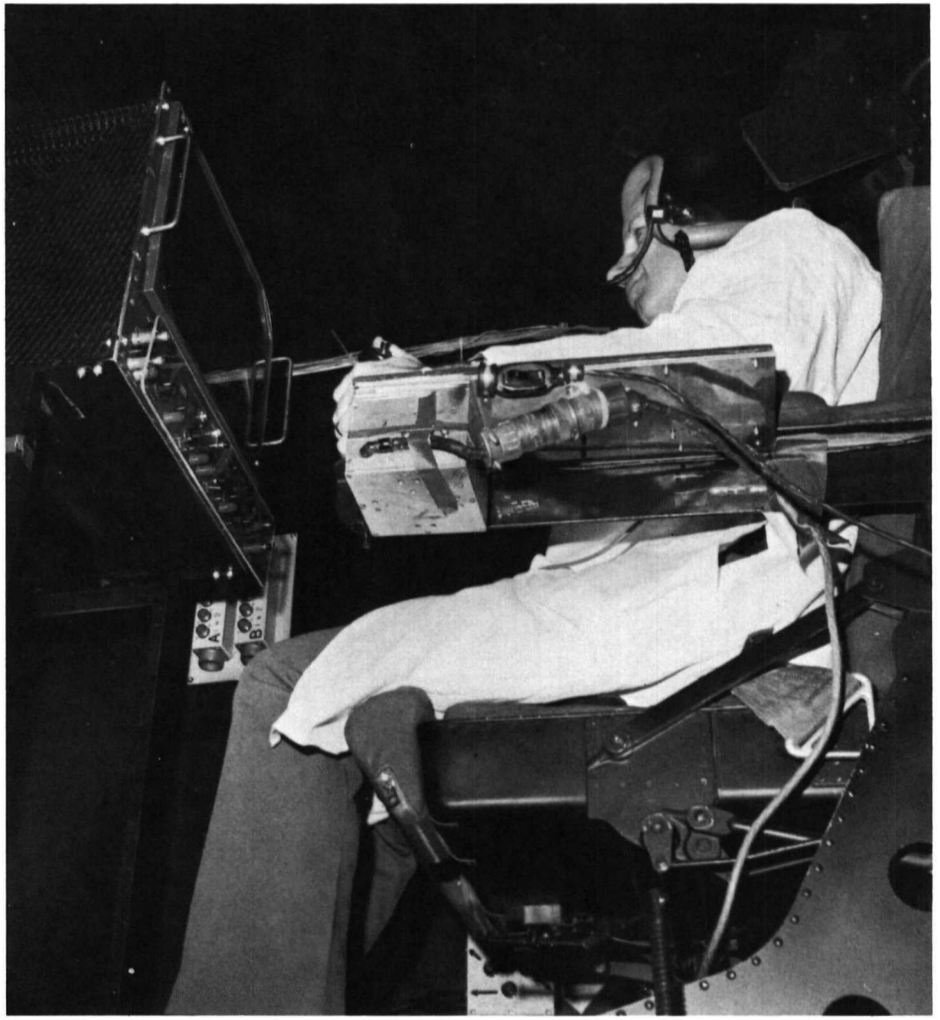
JURISDICTION:

Life Sciences Directorate
Edward M. Huff

LOCATION:

Building N-239A





Motion Generated	Displacement	Acceleration	Velocity
About Vertical Axis	Unlimited	0.52 Rad/sec^2 (max.)	4.7 Rad/sec
	Unlimited	0.007 Rad/sec^2 (min.)	4.7 Rad/sec

7. TWENTY-G CENTRIFUGE

DESCRIPTION:

The Twenty-G Centrifuge is used to investigate the high-g tolerances of biological subjects and specimens, as well as of instrument packages and thus determine their flight qualifications. Preset velocity-time profiles, for example, have been obtained during continuous centrifugation of 27 days at 2.5g and 20-plus days at 16g. This centrifuge has a double-ended arm construction with cabs at both ends. The arm radius to the center of the cab is 25 feet. The test cab size is 6′ x 7′ x 8′, with a maximum payload at each end of 1200 pounds or 16,000 g-pounds. Additional equipment weighing up to 2000 lbs. can be mounted within four feet of the center of rotation.

DRIVES:

Electrical servos

STATUS:

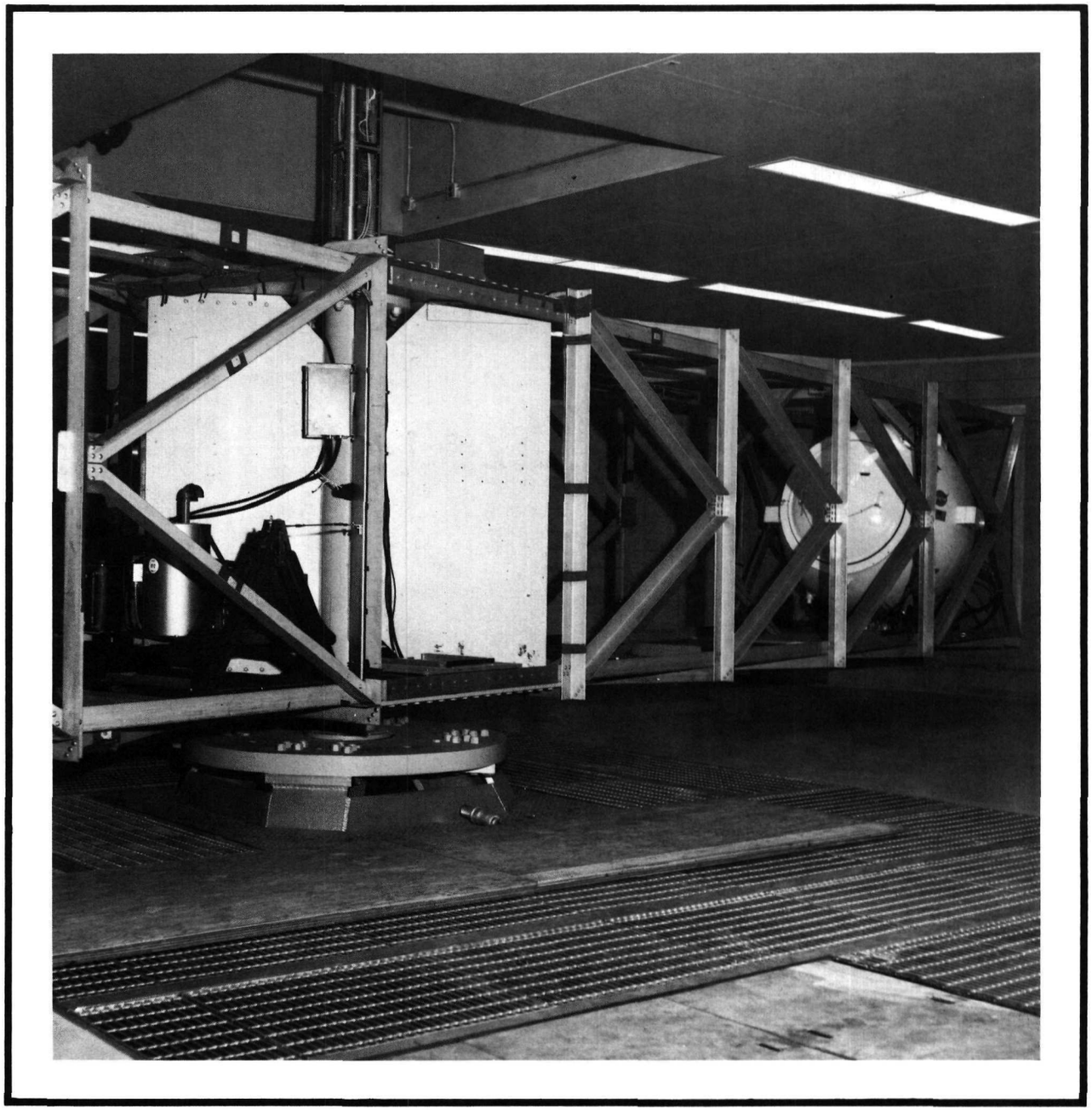
Operational since 1964

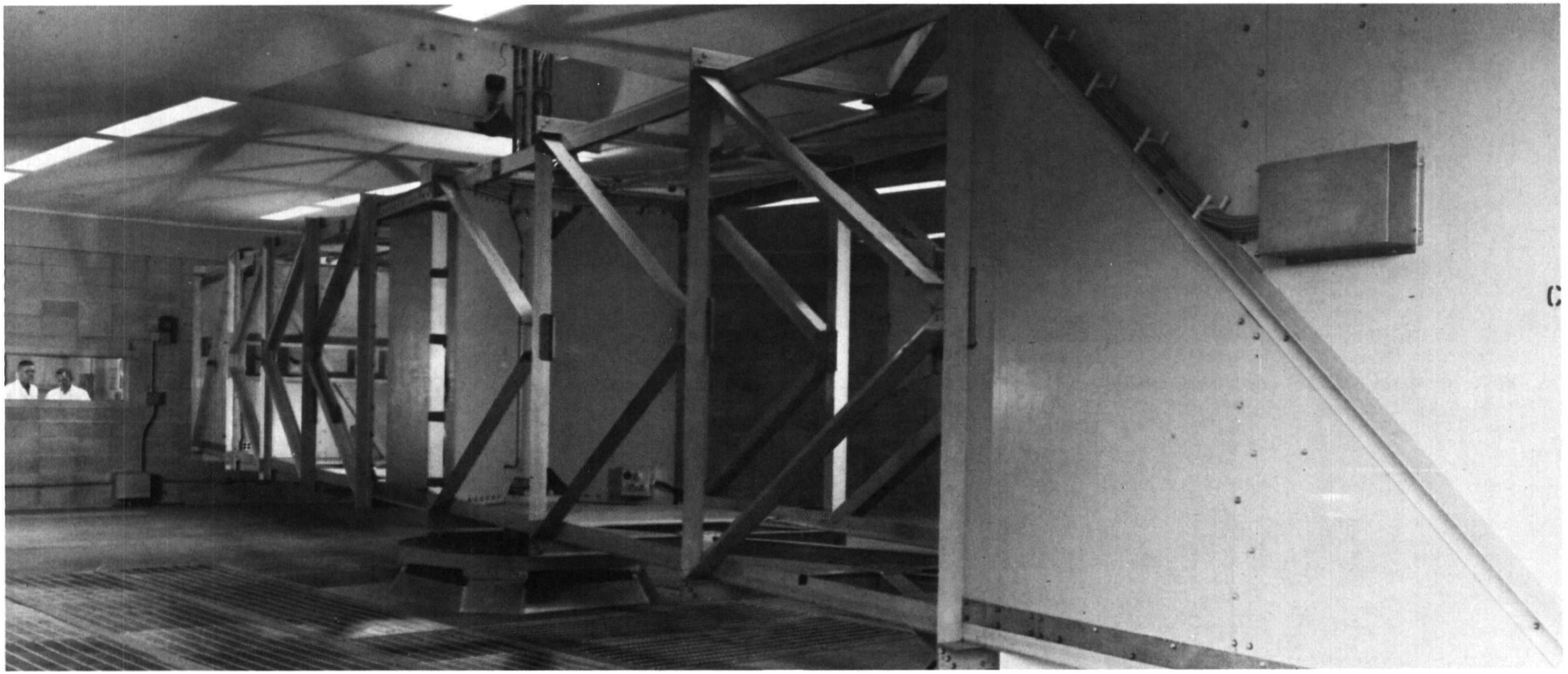
JURISDICTION:

Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-221





Motion Generated	Displacement	Acceleration	Velocity
Arm (Angular)	Unlimited		5 Rad/sec (max.)
			0.012 Rad/sec (min.)
Arm (Radial)		20 g (max.)	
		12.5 g max. (Man-Rated)	
(Radial Onset)		2 g/sec	

8. THE SIX-DEGREE-OF-FREEDOM MOTION SIMULATOR

DESCRIPTION:

The Six-Degree-of-Freedom Motion Simulator is used to investigate the handling and general flying qualities of vertical rising aircraft particularly during take-off and landing. It has a single cockpit cab outfitted with stick-type flight controls. The cab is normally closed and is provided with a TV monitor, panel instruments, "force-feel" flight controls, and stereo cockpit sounds. However, the cab may be left open to provide a one-to-one simulation using the "real" world. Aircraft dynamics are provided by an EAI 8400 digital computer (32,000 word memory) and/or an EAI 231R analog computer used in the closed-loop mode.

DRIVES:

Ward-Leonard electrical servos
Torque motors drive through silent chains to rubber-faced sectors or to cable-pulling drums.

STATUS:

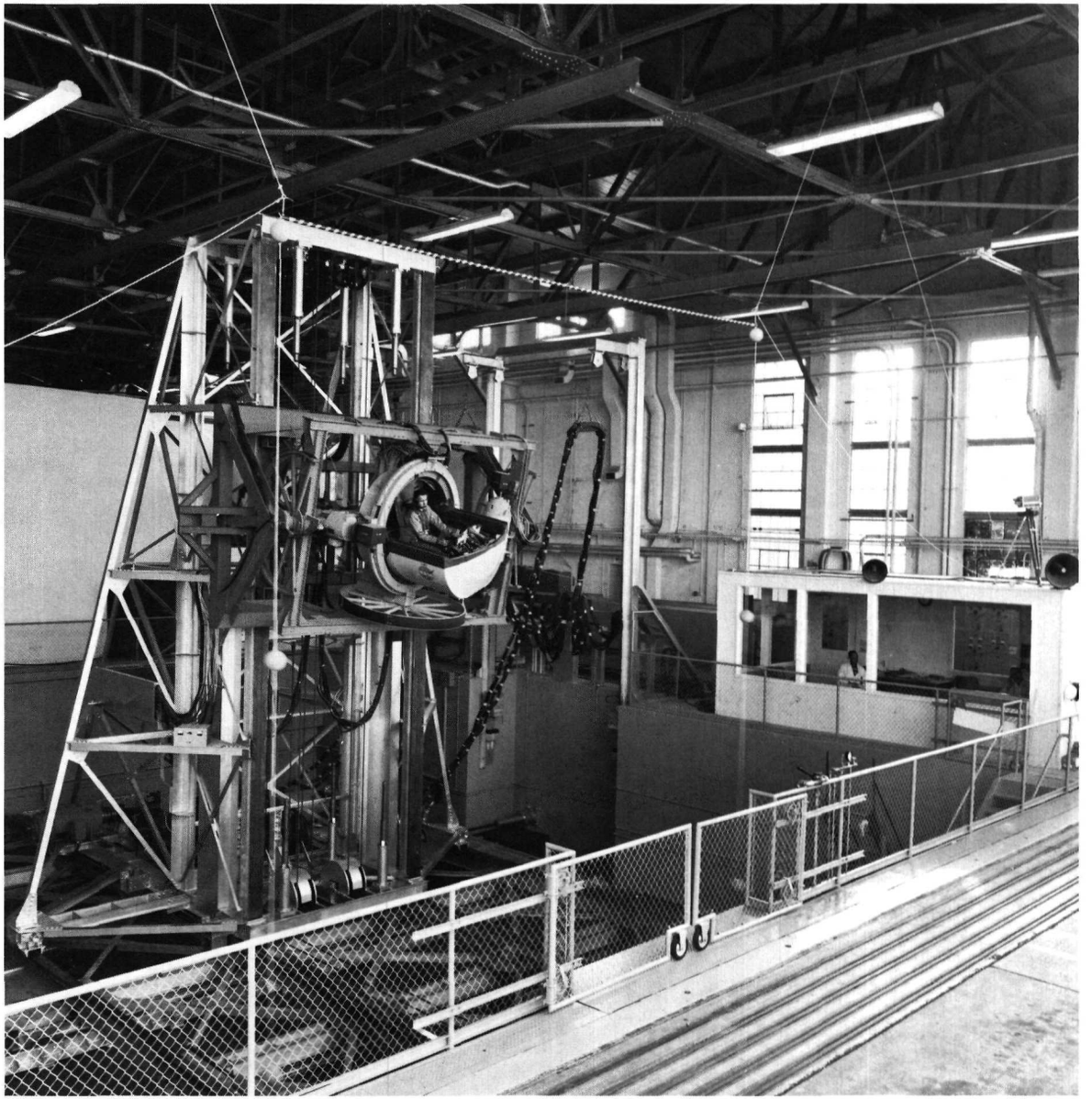
Operational since 1964

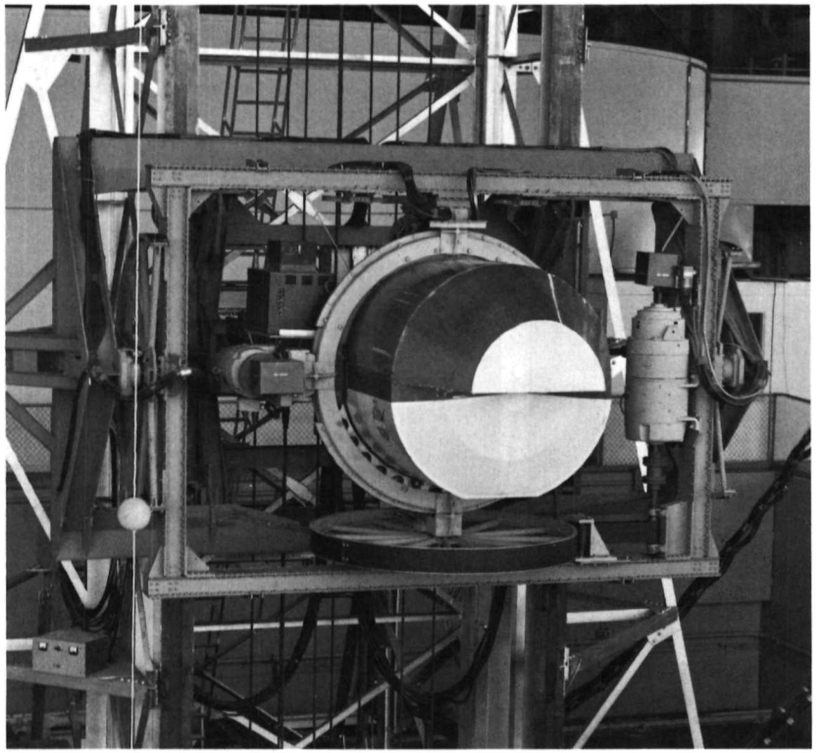
JURISDICTION:

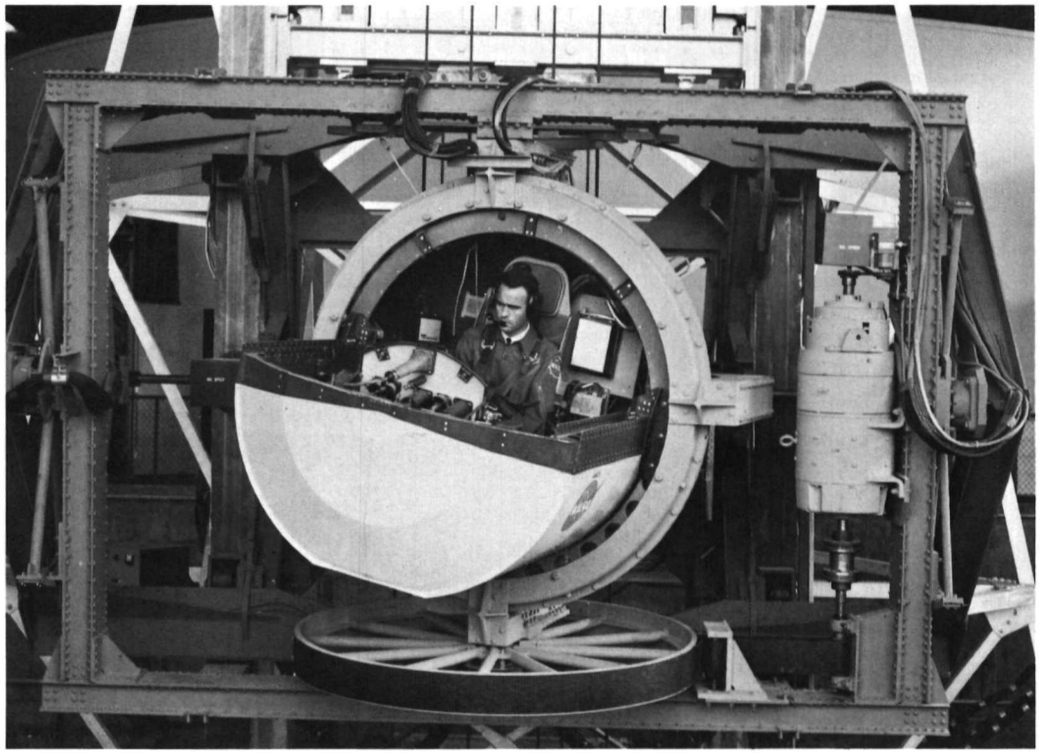
Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Building N-210







Motions Generated	Displacement	Acceleration	Velocity	Frequency At 30° Phase Lag
Roll	±35°	10 Rad/sec^2	1.3 Rad/sec	0.63 Hz
Yaw	±35°	3.0 Rad/sec^2	3.0 Rad/sec	0.70 Hz
Pitch	±35°	4.5 Rad/sec^2	1.7 Rad/sec	0.55 Hz
Vertical	±9 ft	8.8 ft/sec^2	7.5 ft/sec	0.20 Hz
Longitudinal	±9 ft	7.5 ft/sec^2	9.0 ft/sec	0.24 Hz
Lateral	±9 ft	9.2 ft/sec^2	8.0 ft/sec	0.54 Hz

9. FIXED-BASE TRANSPORT SIMULATOR

DESCRIPTION:

The Fixed-Base Transport Simulator is primarily used to study flight management procedures and crew performance with advanced cockpit display/control configurations. The two seat cab may be used with either a virtual image TV display for day scenes, or a digitally generated collimated CRT display for night scenes. The cab is equipped with both conventional aircraft panel instruments and a general purpose, high resolution CRT display for simulating advanced avionics systems. This simulator is used in the closed-loop mode with pilot controls that are connected to hydraulic loaders for variation of control system parameters. Aircraft sounds are simulated to induce realism and to provide auditory cues for the pilot. Aircraft and wind dynamics for visual scenes and instrument displays are provided by either an SEL-840MP digital computer or an EAI 84000 computer. Representative research using this simulator includes studies of Space Shuttle energy management, STOL aircraft navigation, and elevated STOL port landing procedures.

DRIVES:

None

MOTIONS SIMULATED:

None

STATUS:

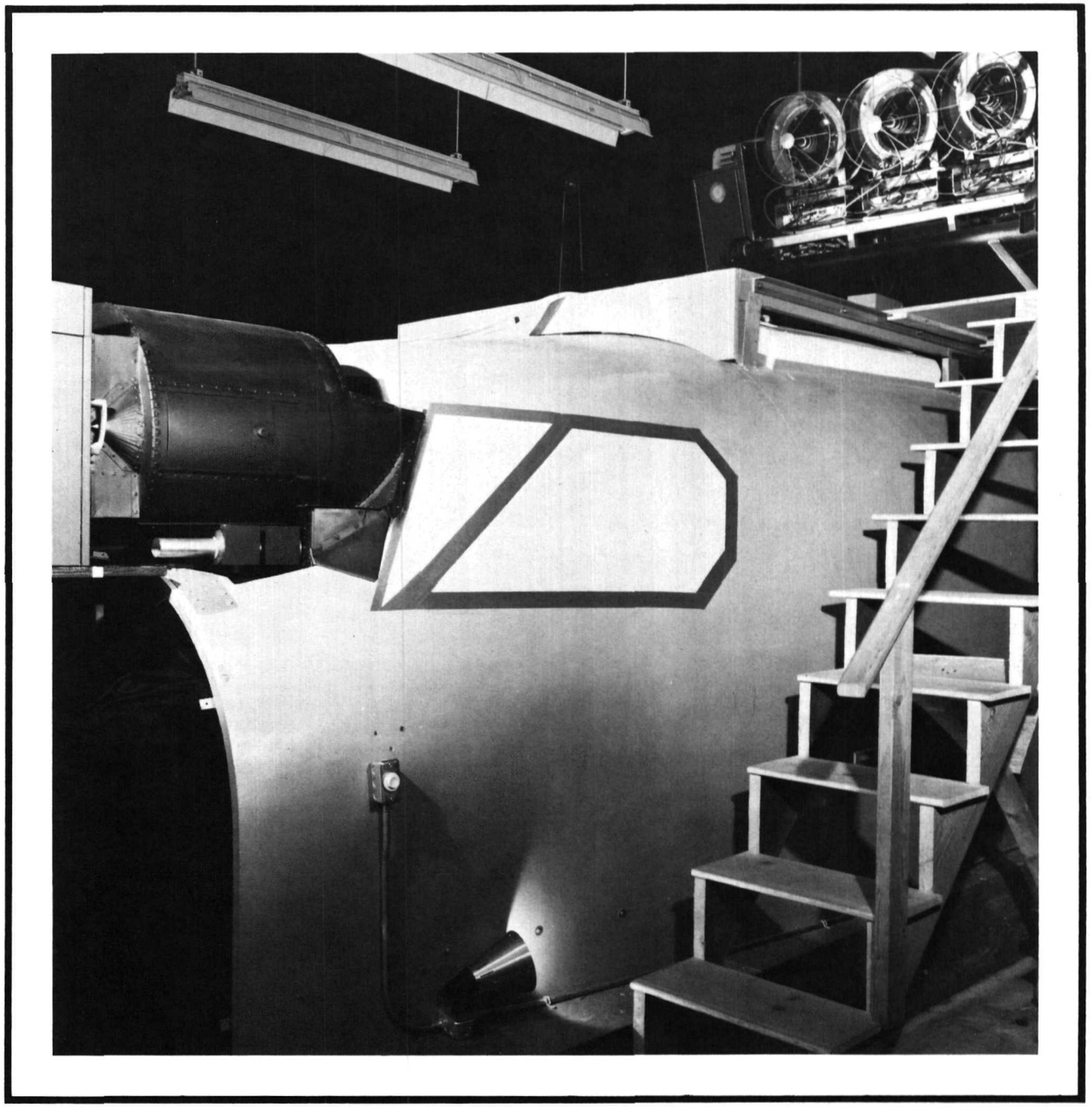
Operational since 1967

JURISDICTION:

Life Sciences Directorate
Edward M. Huff

LOCATION:

Building N-239A



10. VISUAL SCENE PRESENTATION SYSTEMS

DESCRIPTION:

Visual Scene Presentation Systems or Visual Flight Attachments are used in conjunction with the various Flight Simulators to provide the pilot with a color or black and white representation of a visual scene as would be observed during approach, landing, take-off, and taxiing exercises on conventional, STOL and V/STOL runways and on aircraft carriers under varying lighting, cloud, and visibility conditions, by means of a closed-circuit TV system. Three such attachments are described here, two manufactured by Redifon Limited, Crawley, Sussex, England, Visual Flight Attachments II and VII; one manufactured by Redifon Air Trainers Limited, Aylesbury, Bucks, England, Visual Flight Attachment IV.

DRIVES:

Visual Flight Attachments II & VII, Electrical Servo-Position
Visual Flight Attachment IV, Electrical Servo-Position (three linear drives can be driven by rate inputs)

STATUS:

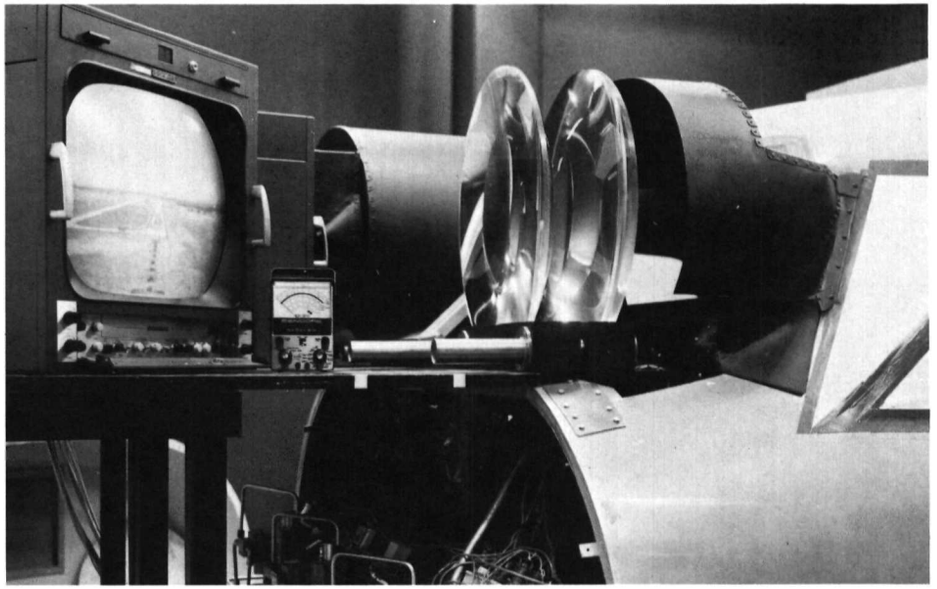
Operational since 1965 (II), 1967 (IV), 1973 (VII)

JURISDICTION:

Simulation Sciences Division
George A. Rathert, Jr.

LOCATION:

Buildings N-210, N-243, and N-239A

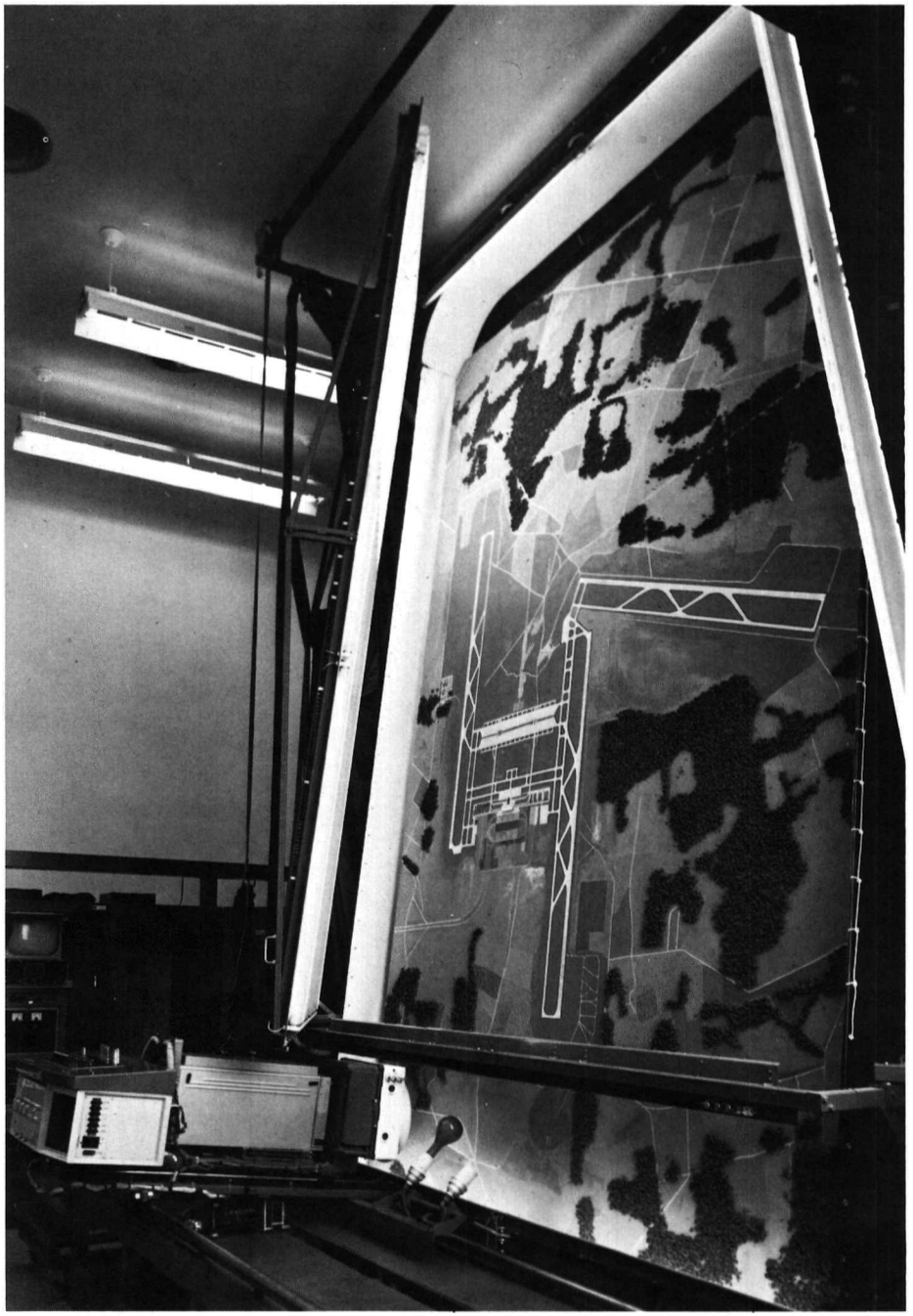


VISUAL FLIGHT ATTACHMENT IV

Mechanical Characteristics	Displacement	Acceleration	Velocity	Frequency At 10° Phase Lag
Roll	340°	100 Rad/sec^2	13 Rad/sec	4.2 Hz
Pitch	50°	8.75 Rad/sec^2	3.5 Rad/sec	3.5 Hz
Yaw	340°	14.8 Rad/sec^2	11.2 Rad/sec	2.9 Hz
Lateral	7 ft (1.60 miles*)	1.65 ft/sec^2 (60g*)	0.55 ft/sec (390 knots*)	0.31 Hz
Longitudinal	30 ft (6.8 miles*)	1.62 ft/sec^2 (60g*)	0.62 ft/sec (444 knots*)	0.09 Hz
Vertical (max.)	1 ft (1200 ft*)	0.5 ft/sec^2 (18.6g*)	0.233 ft/sec (16,740 ft/min*)	0.48 Hz
(min.)	0.072 in. (7.2 ft*)			
*at scale of 1:1200				

VISUAL FLIGHT ATTACHMENT II				
Mechanical Characteristics	**Displacement**	**Acceleration**	**Velocity**	**Frequency At 30° Phase Lag**
Roll	±100°	90 Rad/sec^2	50 Rad/sec	2.8 Hz
Pitch	+20°, –30°	22 Rad/sec^2	3 Rad/sec	2.8 Hz
Yaw	+70°, –250°	30 Rad/sec^2	3.3 Rad/sec	2.8 Hz
Lateral	9 ft (±0.5 mile*)	0.45 ft/sec^2 (8.5g*)	0.5 ft/sec (180 knot*)	0.42 Hz
Longitudinal	35 ft (4 mile*)	0.80 ft/sec^2 (15g*)	0.53 ft/sec (185 knot*)	0.52 Hz
Vertical (max.)	1.25 ft(750 ft*)			
(min.)	0.17 in. (85 ft*)	0.24 ft/sec^2 (5.5g*)	0.093 ft/sec (3300 ft/min*)	0.75 Hz
*at scale of 1:600 (can be varied)				

VISUAL FLIGHT ATTACHMENT VII				
Mechanical Characteristics	**Displacement**	**Acceleration**	**Velocity**	**Frequency At 30° Phase Lag**
Roll	±180°	90 Rad/sec^2	5.5 Rad/sec	2.8 Hz
Pitch	±25°	22 Rad/sec^2	2.5 Rad/sec	2.9 Hz
Yaw	Continuous	30 Rad/sec^2	3.3 Rad/sec	2.9 Hz
Longitudinal	64 ft. (10.9 miles*)	1.00 ft/sec^2 (28g)	0.68. ft/sec (360 knots*)	2.8 Hz
Lateral	15 ft (2.5 miles*)	1.00 ft/sec^2 (28g)	0.9 ft/sec (480 knots*)	2.9 Hz
Vertical (max.)	4 ft (3600 ft.*)	1.8 ft/sec^2 (50g)	1.4 ft/sec (75,600 ft/min*)	3.2 Hz
(min.)	0.072 in. (5.4 ft.*)			
*at scale of 1:900 (can be varied)				



11. COMPUTER GRAPHIC VISUAL DISPLAY SIMULATOR

DESCRIPTION:

The Computer Graphic Visual Display Simulator is a general purpose, high resolution graphics system manufactured by Evans & Sutherland Computer Corporation (model LDS-2). It can be used to create through-the-window night visual scenes with or without superimposed head-up display symbology, or to generate advanced cockpit display configurations including EADI, R-NAV, Datalink, collision warning, air-traffic, and system status displays. When used for generating through-the-window scenes, the pilot sees the computer symbology through a set of collimating lenses. The airport/city scene can contain up to 1800 points of light, and any type of symbology that can be represented by lines or points can be presented on the monitor, e.g., head-up display symbology, strobe lights, automobile traffic, buildings, runway markings and other aircraft. When used to simulate panel instrument displays, a sophisticated clipping capability allows the graphic system to present many subsystems simultaneously. This simulator has been used to study Head-Up displays to aid pilots during visual approaches on steep STOL landings, for two-segment noise abatement approaches by commercial transports, and for low visibility conventional approaches and landings. This simulator has also been used to study vertical and horizontal situation displays, computer interactive data entry systems and datalink message formats. In 1974 the system is scheduled to be upgraded with a full color capability for simulating day scenes and commercial type panel instruments.

STATUS:

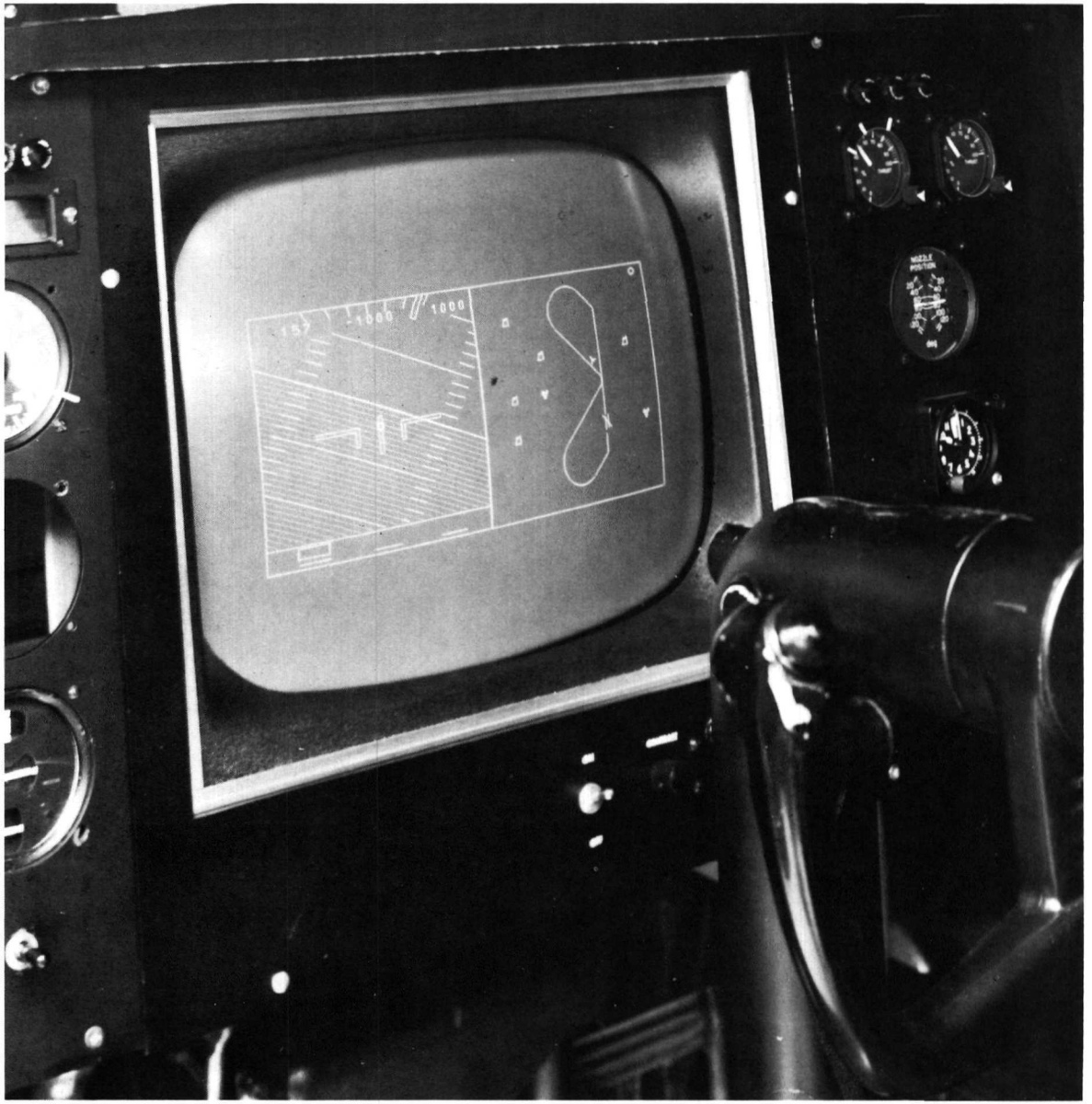
Operational since 1971.

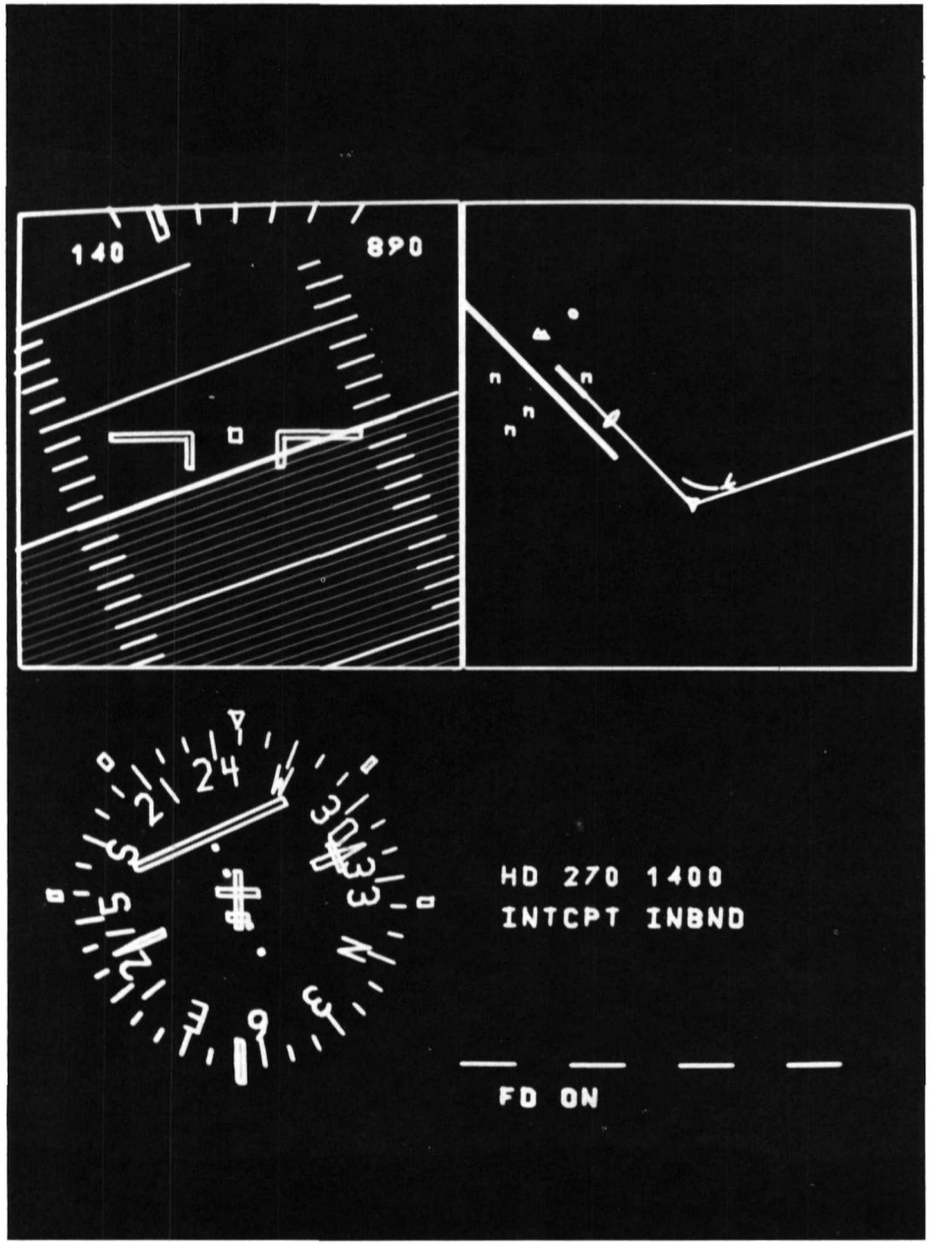
JURISDICTION:

Life Sciences Directorate
Edward M. Huff

LOCATION:

Building N-239

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890
HD 270 1400
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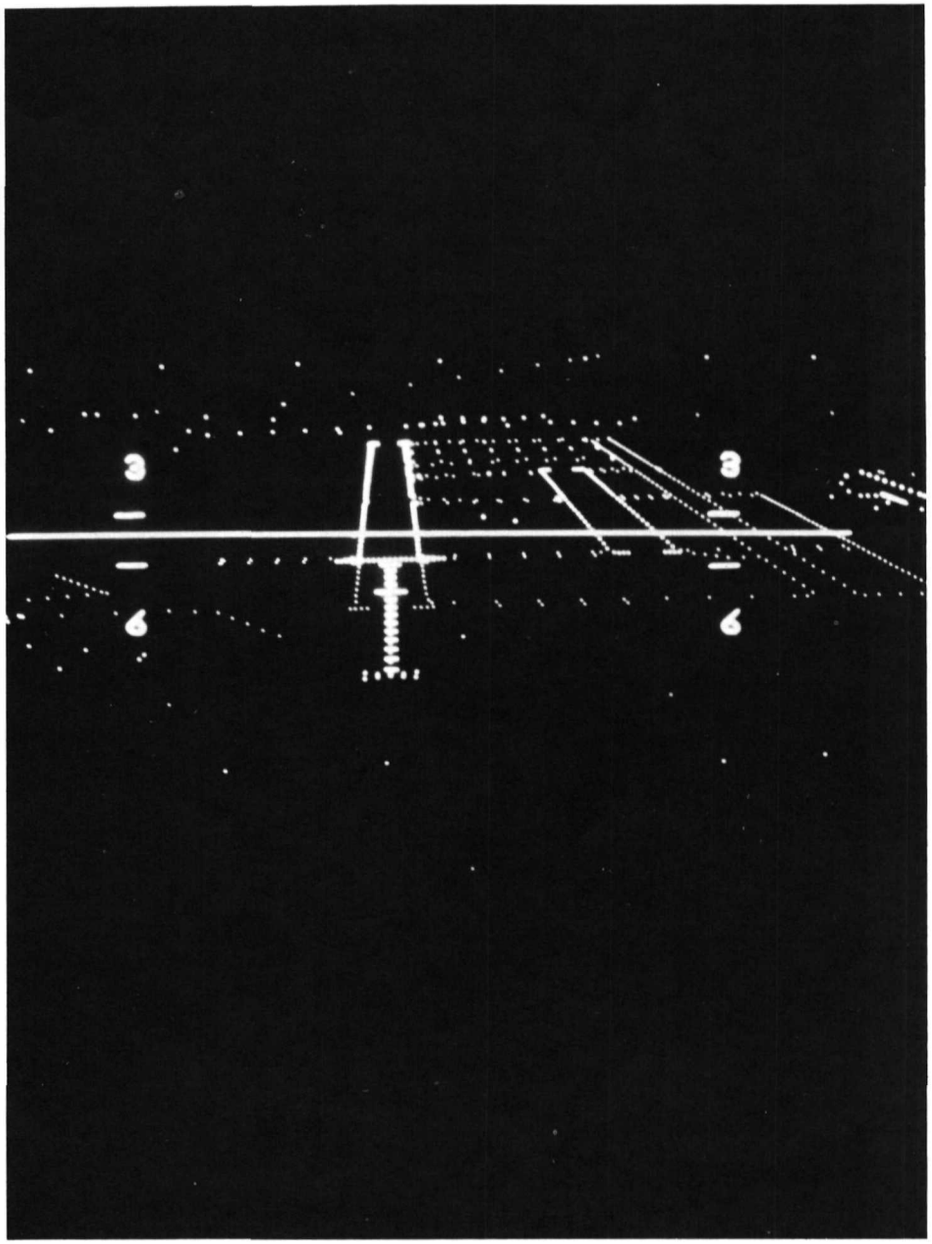
FD ON



12. ENVIRONMENTAL TEST FACILITIES

DESCRIPTION:

Environmental Test Facilities are used for studies involving altitude, atmospheric composition (oxygen, nitrogen, or inert gas, carbon dioxide, carbon monoxide, humidity and combustible hydrocarbons), and temperature or temperature cycling. Two facilities are described here, the Human Environmental Test Facility and the Environmental Chamber. Reduced pressure is obtained and maintained by vacuum pumps in both facilities.

The gaseous atmosphere in the Environmental Chamber is continuously recycled with CO_2 removed by a lithium hydroxide scrubber and humidity controlled by a chilled-water heat exchanger. Oxygen is added continuously to replace consumption losses. Heat may be introduced by means of heaters located in the recirculation ducting and may be removed in the heat exchanger. Fire protection consists of a hose with fog nozzle, a fixed-position fog nozzle and smoke detectors.

Temperature control in the Human Environmental Test Facility is achieved by circulating heated or chilled water through radiant panels on all wall, floor and ceiling surfaces. Since this facility was designed for studies on closed-ecological systems, gas bleeding is the only available means for eliminating humidity, carbon dioxide or other contaminants. Fire protection consists of three hoses with fog nozzles, two fixed-position fog nozzles and smoke detectors.

STATUS:

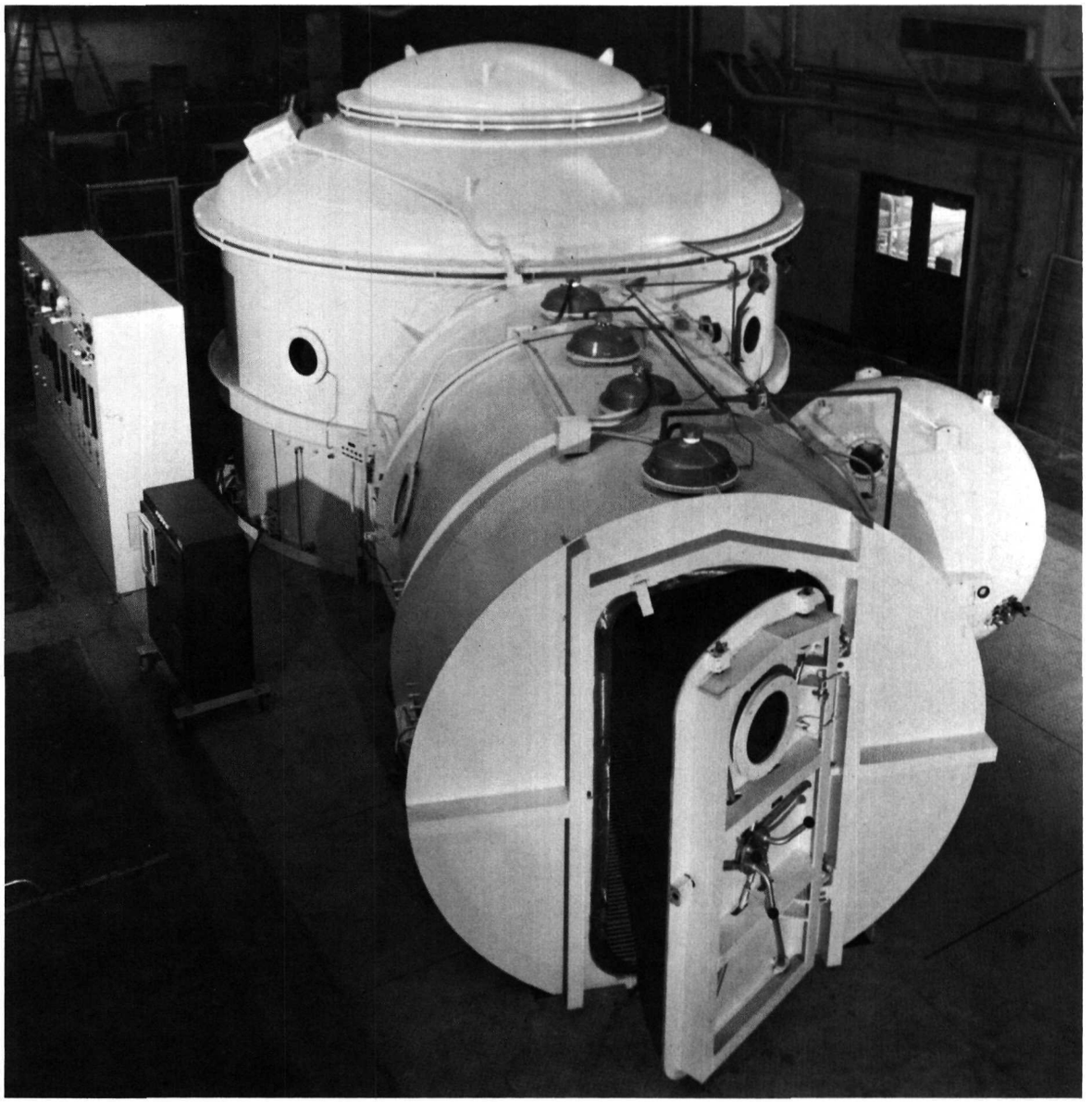
Operational since 1964, 1968

JURISDICTION:

Life Sciences Directorate
Joan V. Danellis

LOCATION:

Building N-239



HUMAN ENVIRONMENTAL TEST FACILITY			
Capability	**Chamber**	**Air Lock**	**Sample Air Lock**
Pressure:	1 to 760 torr	1 to 760 torr	1 to 760 torr
(Altitude)	(S.L. to 150,000 ft.)	(S.L. to 150,000 ft.)	(S.L. to 150,000 ft.)
Pressure Control:	±2.5 torr, max.	±2.5 torr, max.	±2.5 torr. max.
Time to Reach Pressure:	21 min	4 min	2 min
Emergency Recompression			
from 1 torr to 250 torr:	5.25 sec	5.25 sec	
from 1 torr to 760 torr:	17 sec	17 sec	
Operating Temperature Range:	35 to 160°F, ±1°F	35 to 160°F, ±1°F	
Temperature Cycling Time:	30 min		

ENVIROMENTAL CHAMBER		
Capability	**Chamber**	**Air Lock**
Pressure:	1 to 760 torr ±5 torr, max.	1 to 760 torr ±5 torr, max.
Pumpdown Time Sea Level to 250 torr:*	4 min	4 min
to 2.5 torr:	30 min	30 min
Recompression Time from 250 to 750 torr:*	90 sec	90 sec
Operating Temperature Range:	70 to 140°F ±2.5°F	70 to 140°F ±2.5°F
* Chamber and Air Lock Combined.		

13. SPARCS SIMULATION TEST FACILITIES

DESCRIPTION:

The Solar Pointing Aerobee Rocket Control System (SPARCS) Simulation Test Facility is used in the pre-launch preparation and testing of rocket vehicle experiment payloads. It consists of a vertical and horizontal air bearing, a ground telemetry station, a hybrid analog/digital computer simulation facility, a heliostat, and various solar simulators. The three-axis solar acquisition and the fine pointing performance of rocket payloads are simulated in the vertical and horizontal air bearings. The heliostat provides a beam of sunlight to the SPARCS system while it is mounted in the air bearings. During adverse weather conditions, solar simulators are substituted for the heliostat. The telemetry station provides the means to monitor the up and down data links of the vehicle under test. The computer facility enables the prediction of vehicle pointing and stability performance over a wide range of variables, such as payload mass and launch date and time.

STATUS:

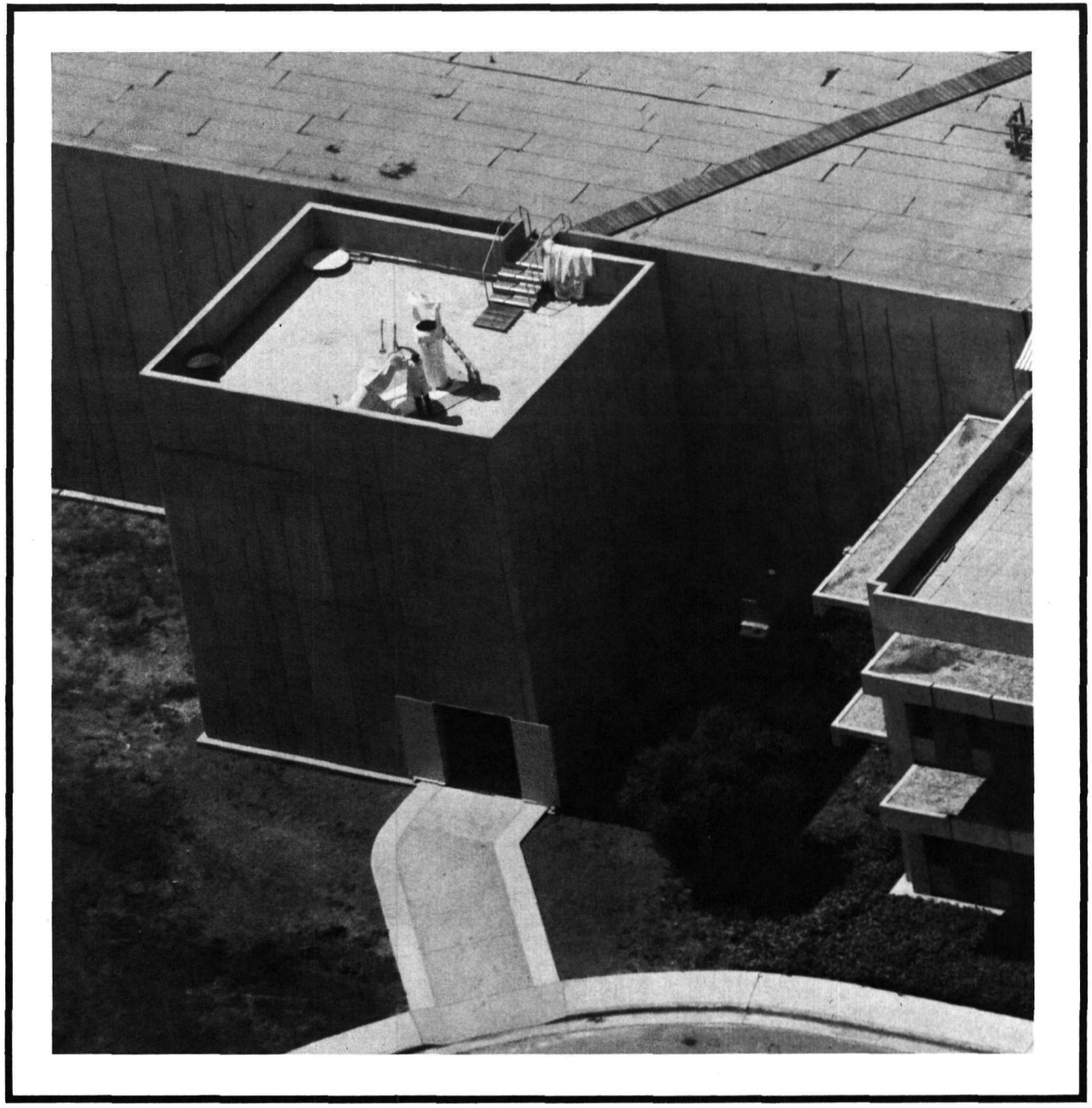
Operational since 1968

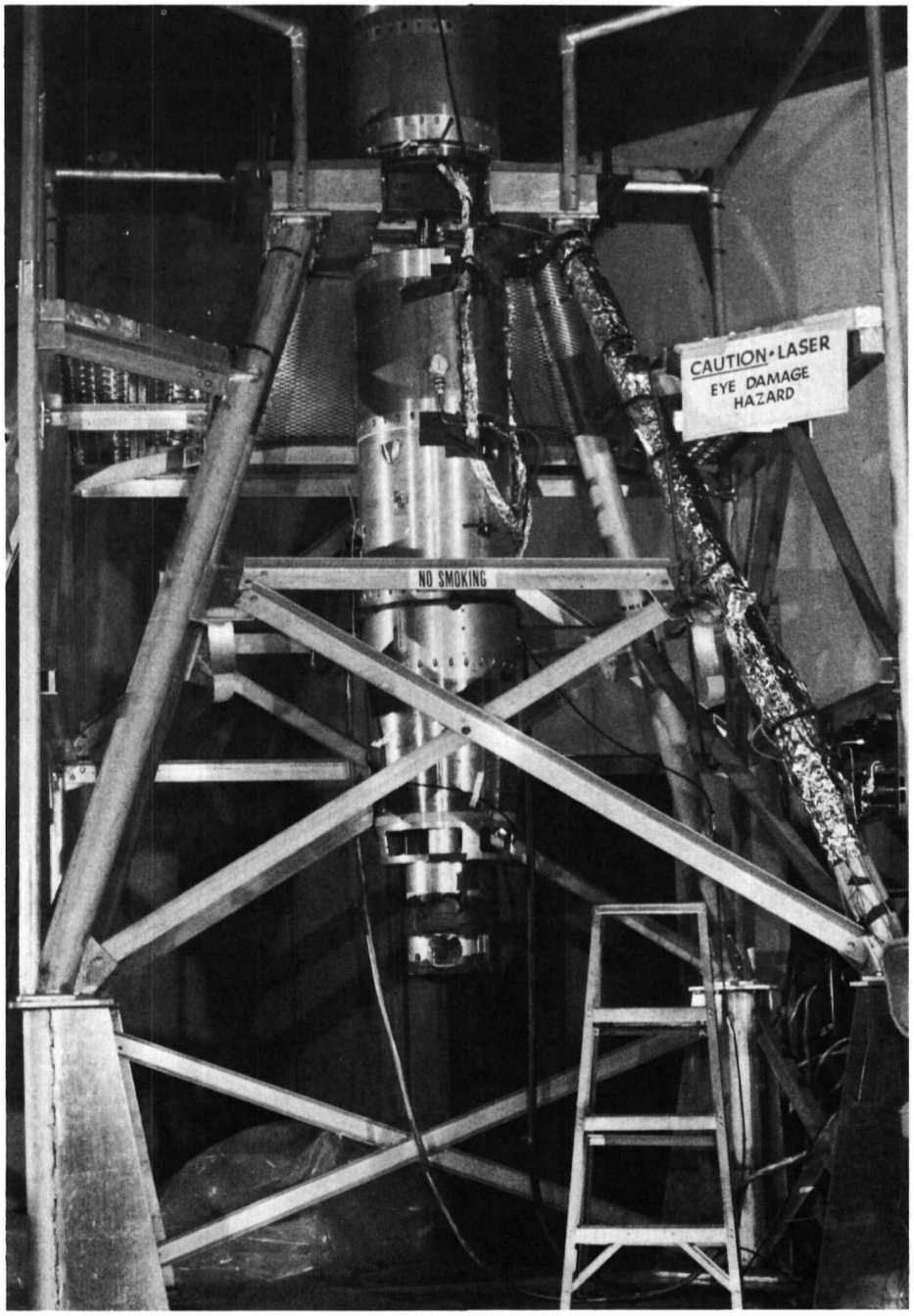
JURISDICTION:

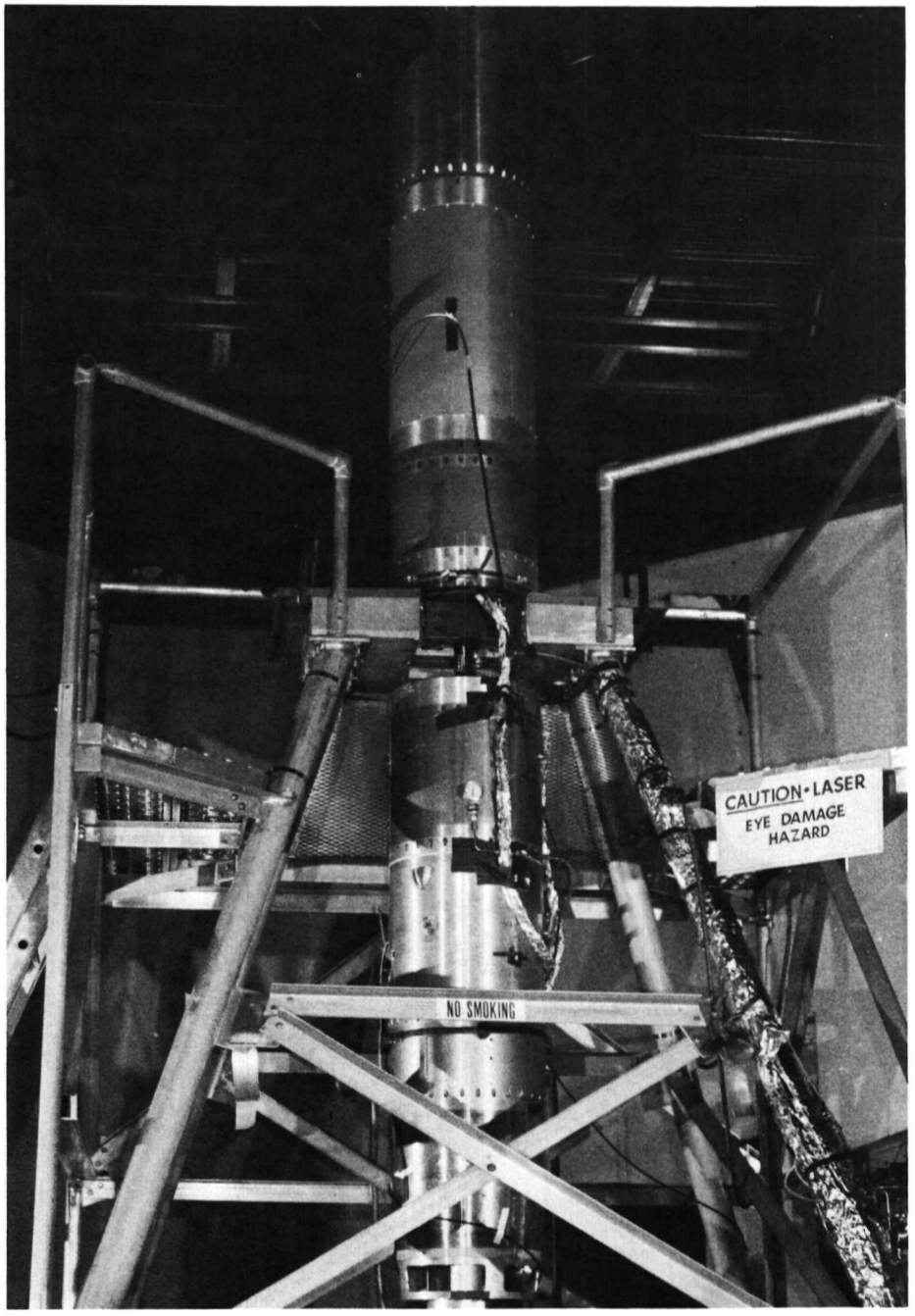
Flight Project Development Division
Q. Marion Hansen

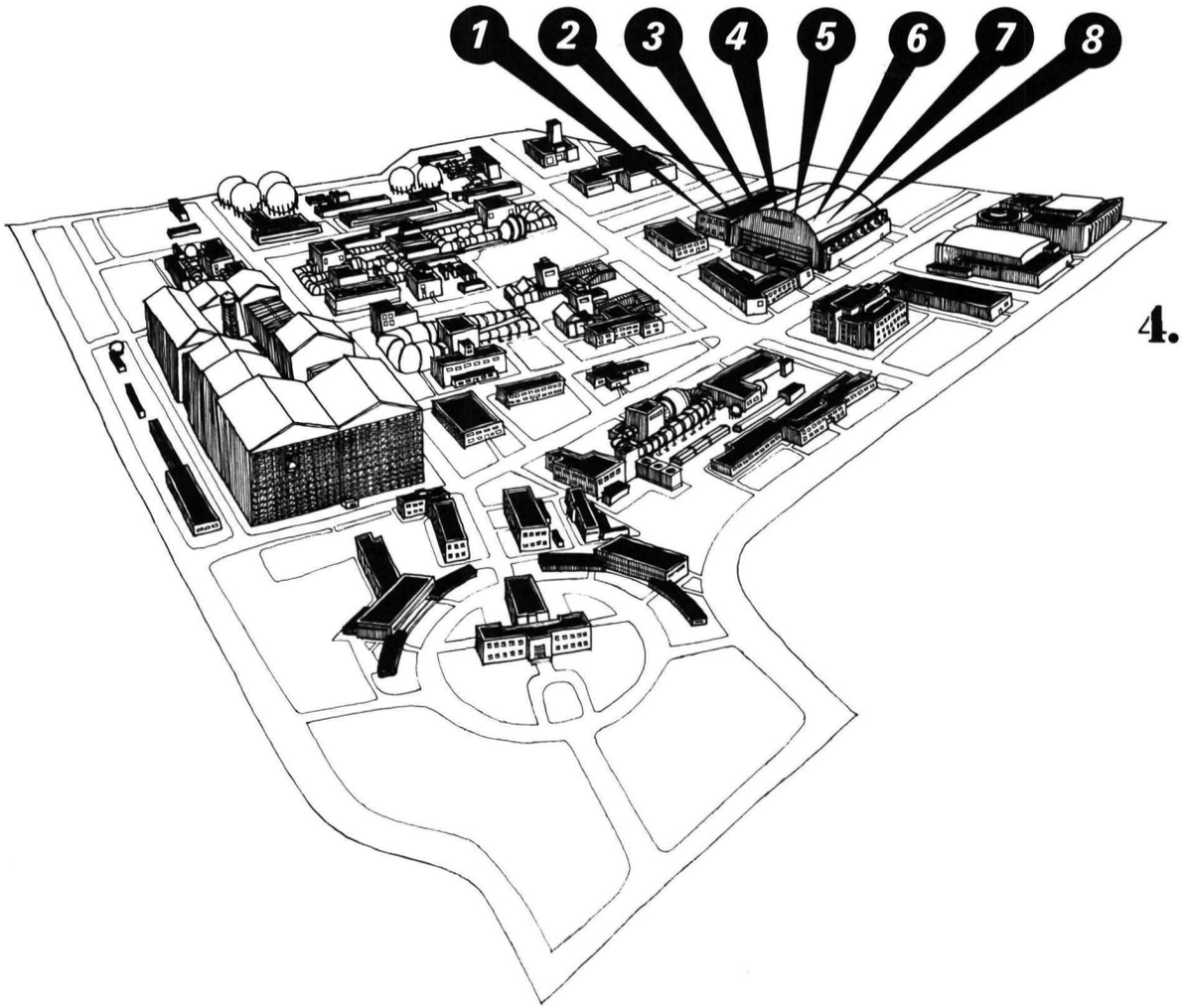
LOCATION:

Building N-244




CAUTION • LASER
EYE DAMAGE
HAZARD
NO SMOKING


CAUTION • LASER
EYE DAMAGE
HAZARD
NO SMOKING



4. RESEARCH AIRCRAFT

1. *C8-A BUFFALO AUGMENTOR WING JET-STOL AIRCRAFT*
2. *CV-340 FLYING LABORATORY*
3. *X-14B VTOL RESEARCH AIRCRAFT*
4. *LEAR 23 AND 24B AIRCRAFT*
5. *CV-990A AIRBORNE RESEARCH LABORATORY*
6. *C-141A AIRBORNE INFRARED OBSERVATORY*
7. *EARTH RESOURCES SURVEY AIRCRAFT*
8. *YOV-10A STOL RESEARCH AIRCRAFT*

4. RESEARCH AIRCRAFT

1. C8-A BUFFALO AUGMENTOR WING JET-STOL AIRCRAFT

DESCRIPTION:

The C8-A Buffalo Augmentor Wing Jet-STOL research aircraft is a modified version of a high-wing, high-tail turboprop Buffalo military transport manufactured by the deHavilland, Ltd., of Canada, and designated NASA 716. It is used to study the design and operational characteristics of jet-STOL aircraft using split-flow turbofan engines to provide both propulsive and augmentor wing jet flows for increased powered-lift. Major modifications to the aircraft include: a) wing span reduced from 96 to 78.8 ft., b) augmentor flap system (including augmentor chokes), c) drooped aileron with boundary layer control, d) repositioned and redesigned spoilers, e) fixed, full-span leading-edge slats, f) T-64 turboprop engines replaced with Rolls Royce Spey split-flow turbofan engines, g) an air distribution duct system to supply fan air to the augmentor flaps, fuselage blowing, and aileron, h) lateral directional stability augmentation system (SAS), i) increased-capacity hydraulic system, and j) extensive flight test instrumentation. This aircraft has a practical operating range of about 300 nautical miles at 160 knots indicated air speed, an operating ceiling of about 15,000 ft., and a useful payload of 2,290 lbs. The modified C8-A Buffalo is being flight tested as part of the augmentor wing jet STOL research program being conducted jointly by NASA and the Canadian Department of Industry, Trade, and Commerce (DITC).

PERFORMANCE:

STOL takeoff weight	45,000 lbs, max.
Basic weight (less fuel and payload)	32,200 lbs
Fuel weight	14,800 lbs
Takeoff distance	<1,500 ft
Landing distance	<1,500 ft

STATUS:

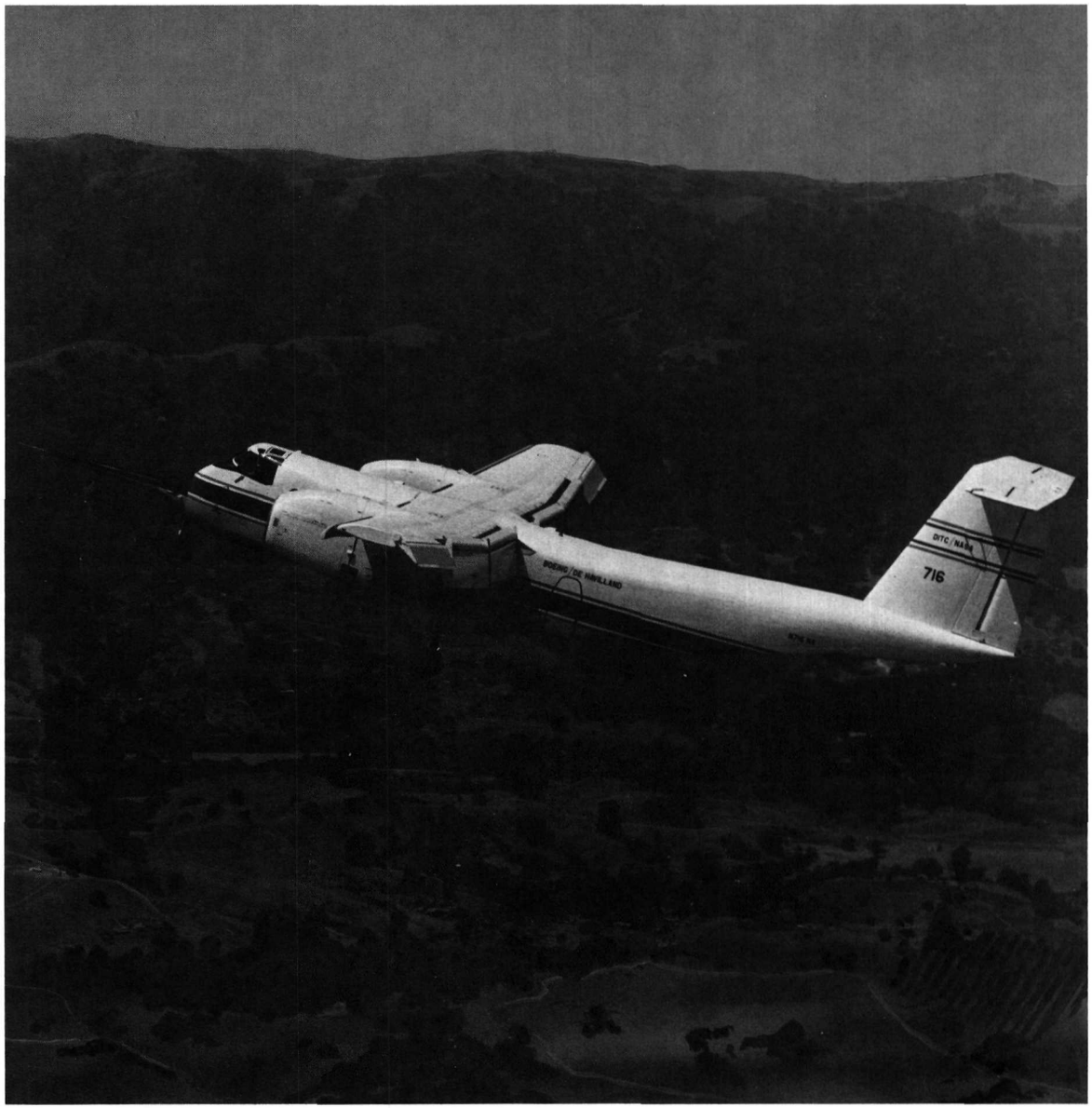
Operational since 1972

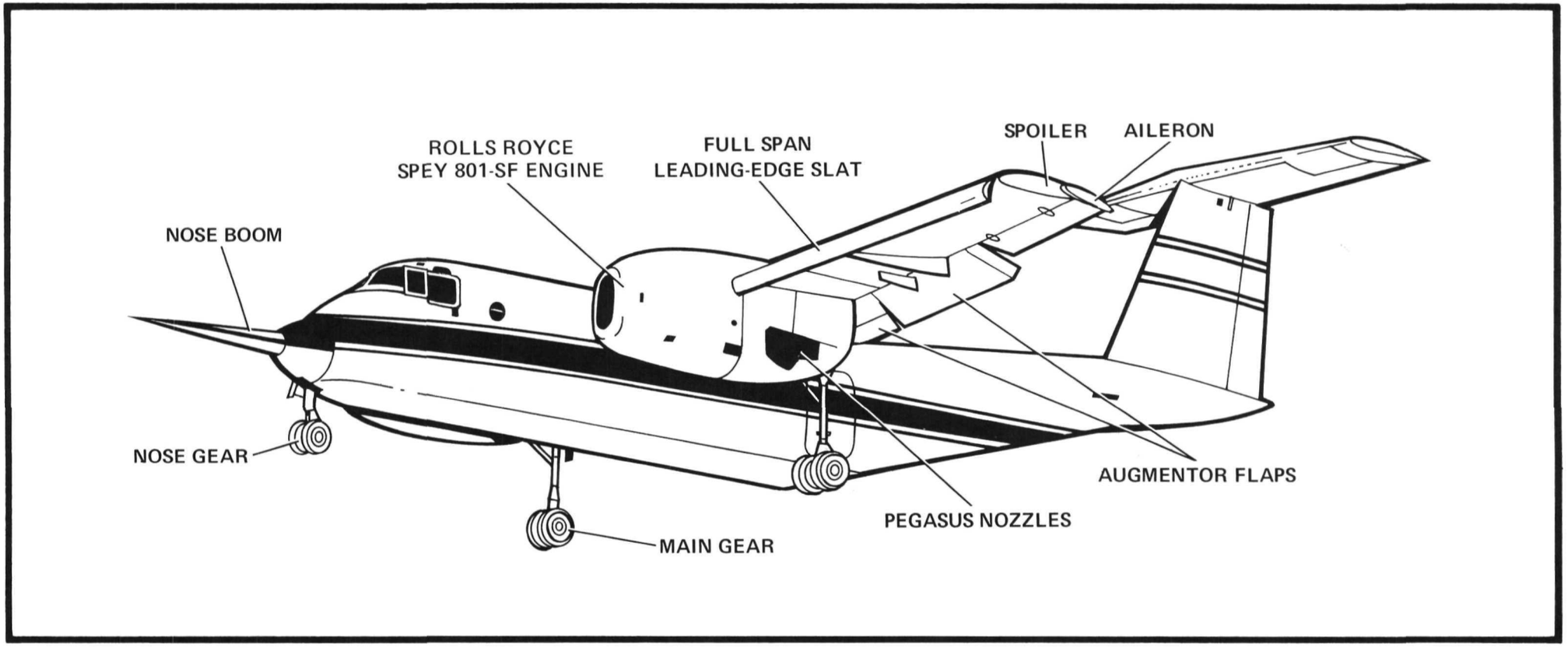
JURISDICTION:

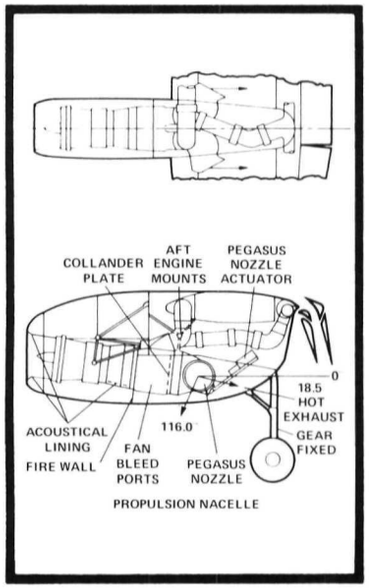
V/STOL Projects Office
Hervey C. Quigley

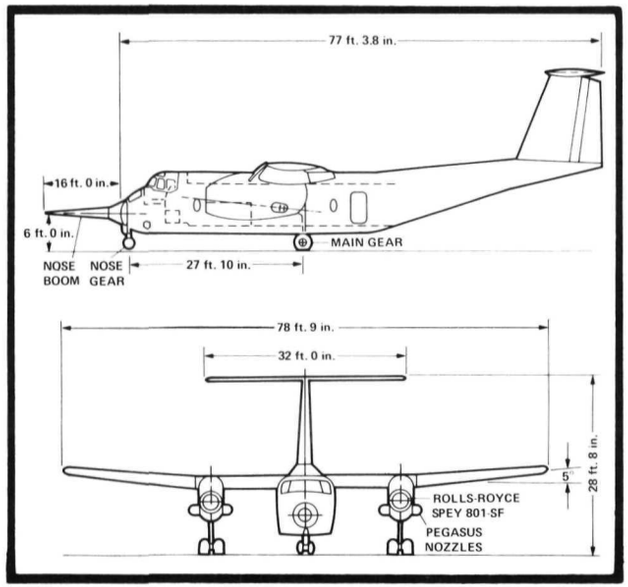
LOCATION:

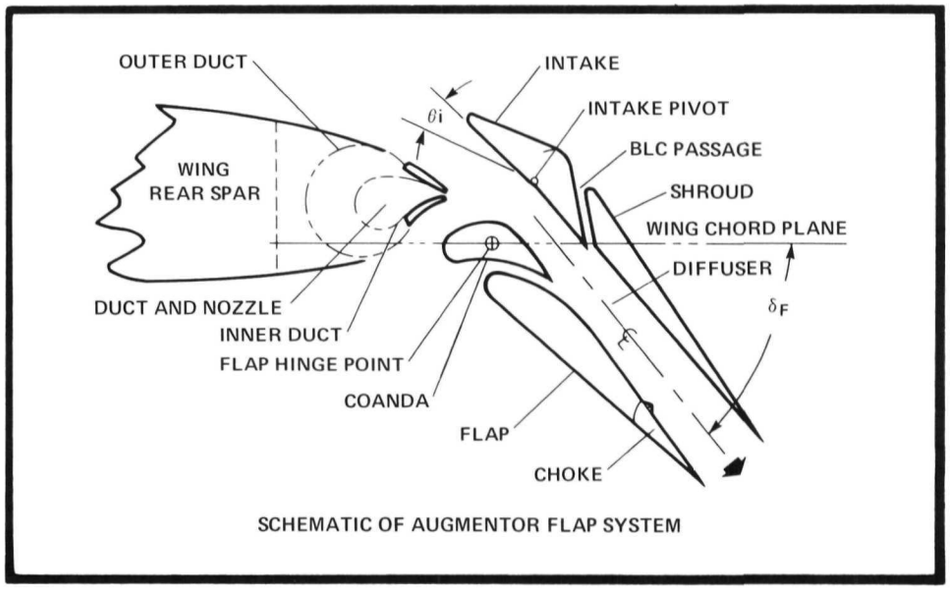
Building N-211











SCHEMATIC OF AUGMENTOR FLAP SYSTEM

2. CV-340 FLYING LABORATORY

DESCRIPTION:

The CV-340 Flying Laboratory is a modified, two engine, low-wing monoplane manufactured by the Convair/General Dyanmics Corporation, and designated NASA 707. It is used for aeronautics research, primarily in support of navigation, guidance and control studies, as well as avionics systems and cockpit display concepts for STOL operations. It has a practical operating range of about 1,000 nautical miles at 210 knots indicated air speed, an operating ceiling of about 20,000 ft., and a useful payload of 6,000 lbs. This aircraft is of all-metal construction, with full cantilever wings, tricycle landing gear, and a conventional, single vertical tail unit. The fuselage is semi-monocoque, pressurized, with passengers (normally 8) above and cargo below. It is equipped with a portable aircraft range measuring system (DMS), a modified Scientific Data System 920 general-purpose digital computer, three CRT-type display units, and 12 strip-chart recorders. The aircraft is supplied power for its standard equipment from engine-driven generators and inverters. Power used for all experimental equipment is supplied from a 14KW gas turbine power plant located in the aft section of the aircraft.

PERFORMANCE:

Takeoff weight	47,000 lbs, max.
Basic weight (less fuel and payload)	36,000 lbs
Fuel weight	10,000 lbs
Takeoff distance	4,000 ft
Landing distance	4,000 ft

STATUS:

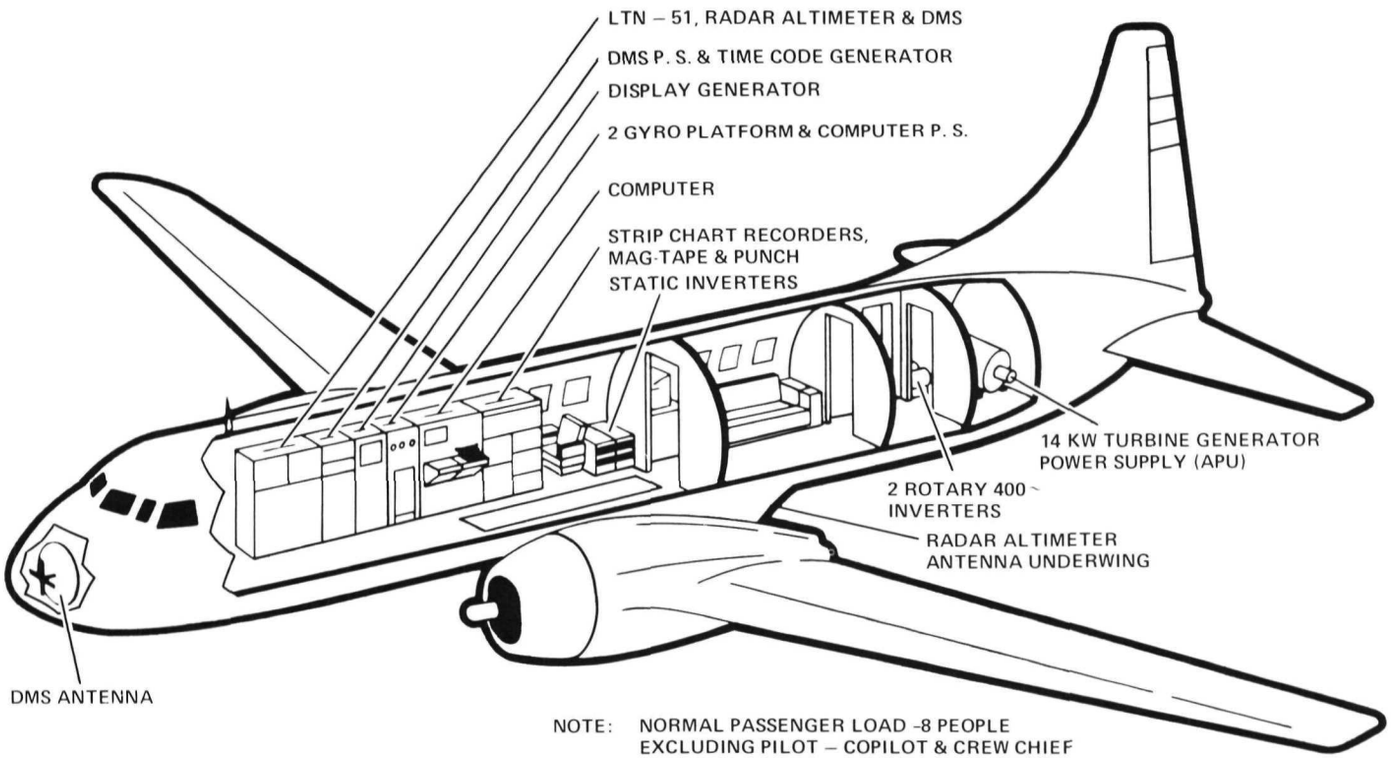
Operational since 1964, refurbished 1973.

JURISDICTION:

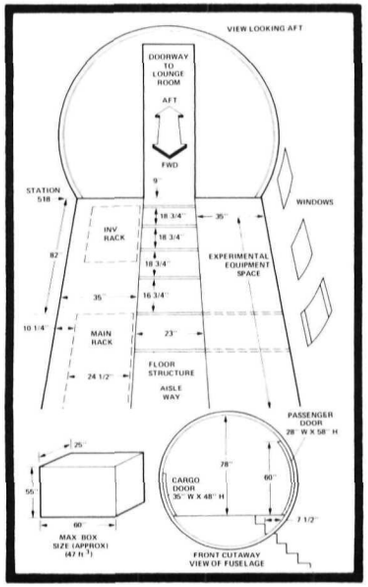
Flight Systems Research Division
Avionics Research Branch
Henry C. Lessing

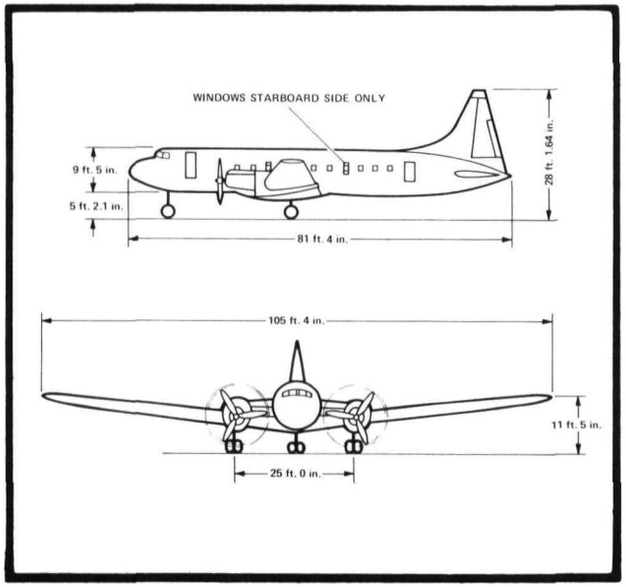
LOCATION:

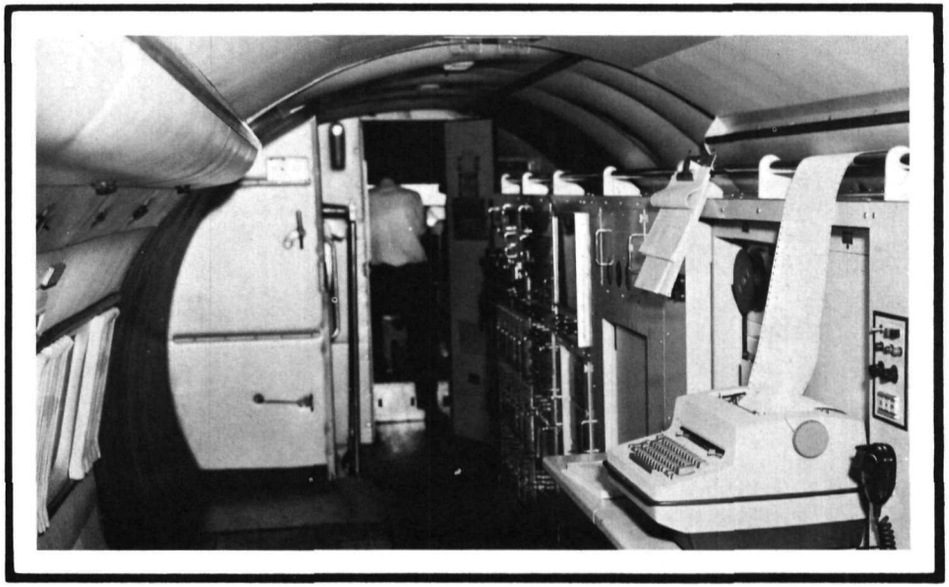
Building N-211



NOTE: NORMAL PASSENGER LOAD -8 PEOPLE
EXCLUDING PILOT – COPILOT & CREW CHIEF







3. X-14B VTOL RESEARCH AIRCRAFT

DESCRIPTION:

The X-14B VTOL Research Aircraft is a variable-stability, variable-control single-place aircraft manufactured by the Bell Corporation, and designated NASA 704. It is a fixed-wing aircraft that has twin engines equipped with cascade-type diverters to vector the jets for any combination of vertical lift or forward thrust. Hovering time is limited to 15 minutes; normal cruise flight time is limited to 20 minutes in normal flight at 120 knots indicated air speed. This aircraft incorporates a unique control and stabilization system known as a model reference (model-following) system. This type of system, which uses an onboard digital computer, permits the synthesis of a wide range of VTOL control systems. It provides the capability for the verification and extension of handling qualities research obtained using ground-based simulators, the comparison of various "optimal" methods of establishing gains for the model following system, and the evaluation of the effectiveness of model following reference systems in minimizing the aircraft's response to external disturbances. This research program is jointly supported by the U.S. Army and NASA.

PERFORMANCE:

Takeoff weight	4,217 lbs, max.
Basic weight (less fuel and payload)	3,470 lbs
Fuel weight (100 gals.)	620 lbs
Takeoff distance (conventional)	~1,000 ft
Landing distance (conventional)	~1,000 ft

STATUS:

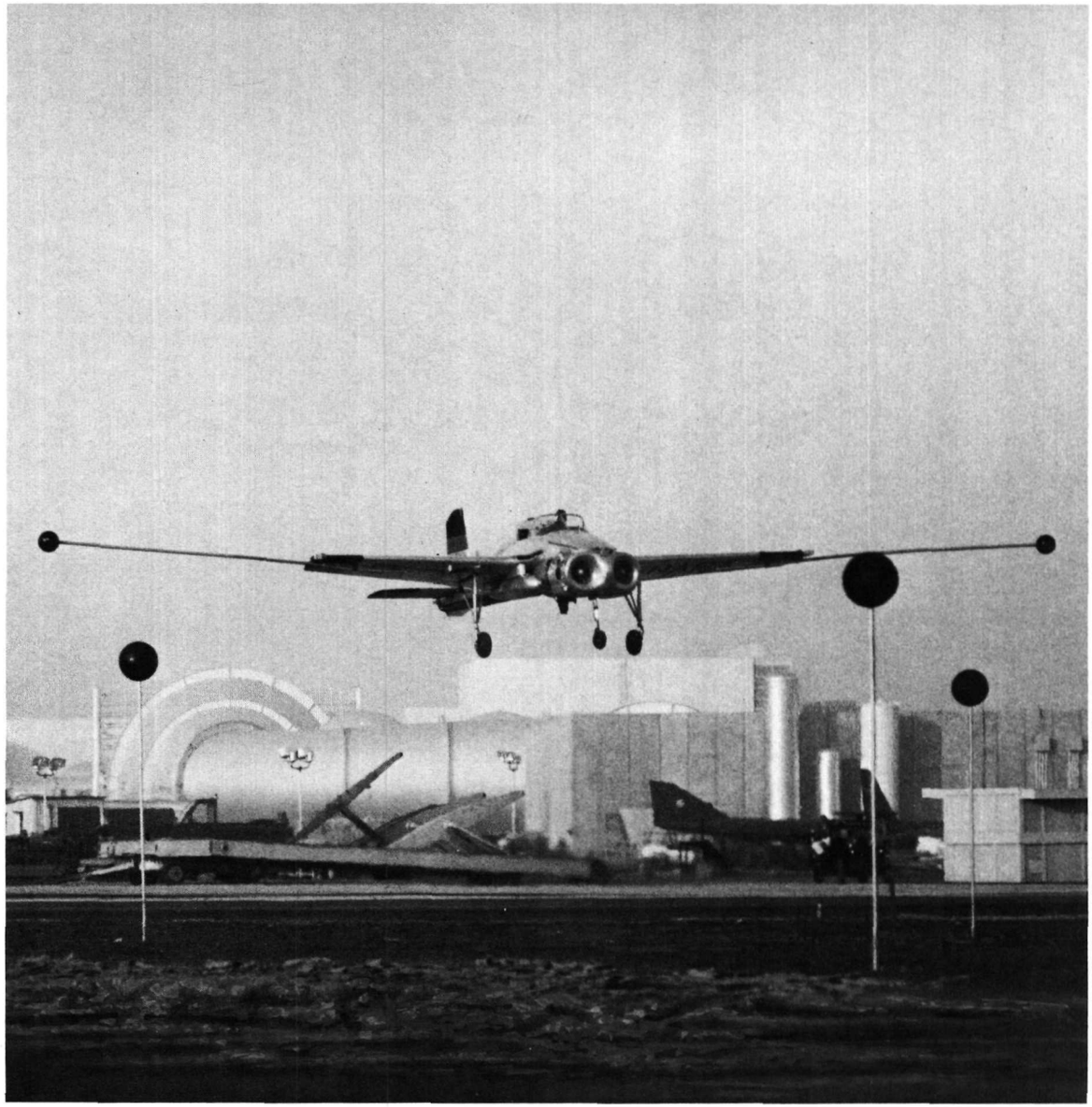
Operational since 1971

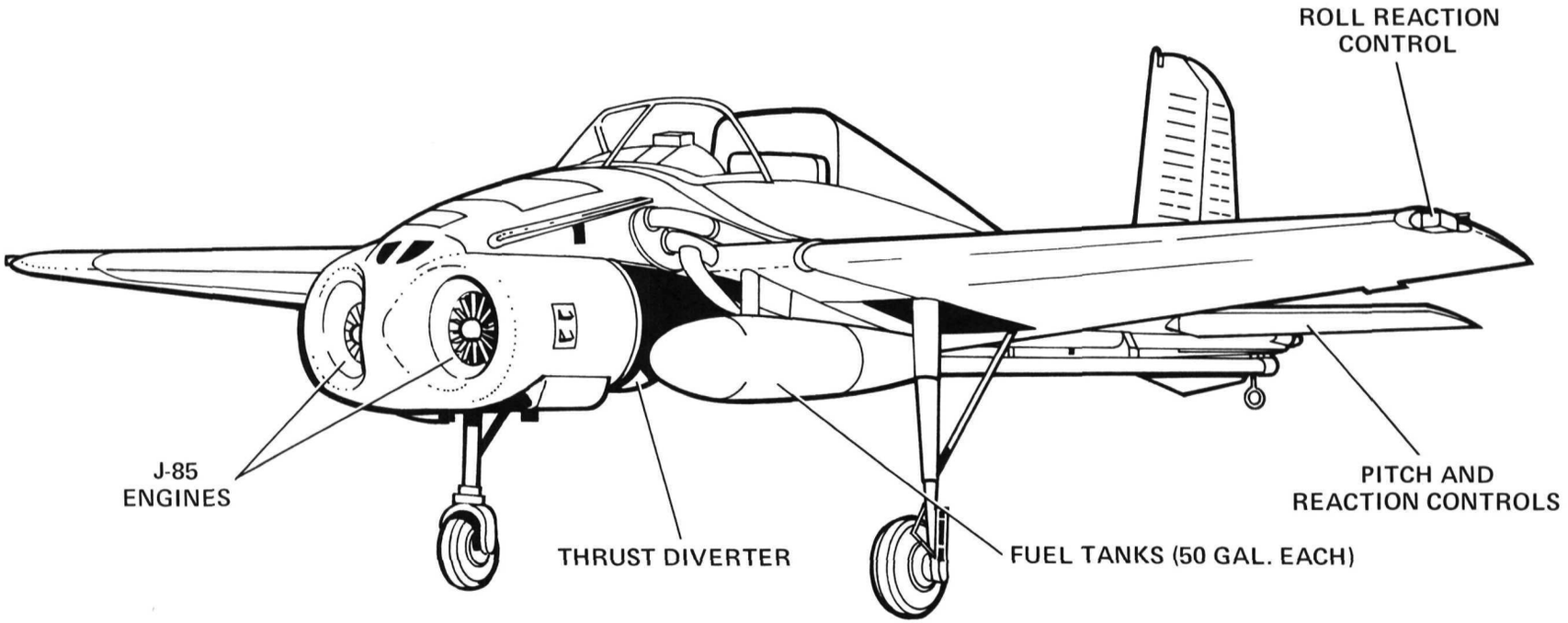
JURISDICTION:

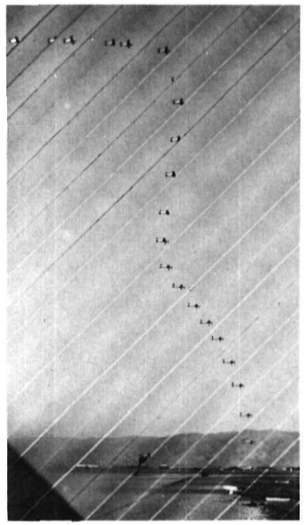
Flight Systems Research Division
Flight and Systems Research Branch
Maurice D. White

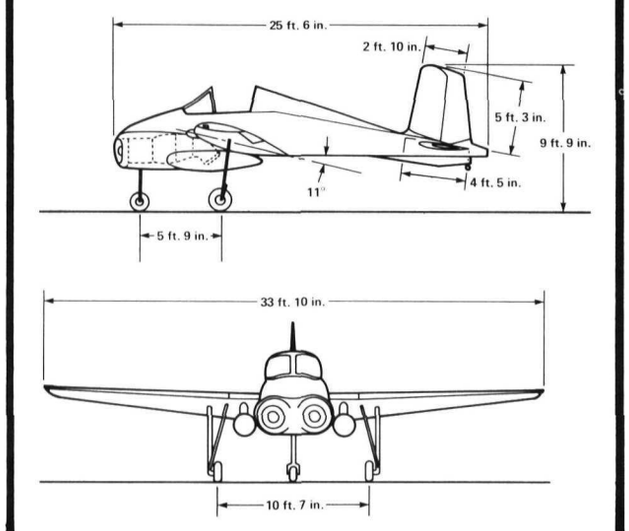
LOCATION:

Building N-211




ROLL REACTION CONTROL
J-85 ENGINES
THRUST DIVERTER
FUEL TANKS (50 GAL. EACH)
PITCH AND REACTION CONTROLS




25 ft. 6 in.
2 ft. 10 in.
5 ft. 3 in.
9 ft. 9 in.
11°
4 ft. 5 in.
5 ft. 9 in.
33 ft. 10 in.
10 ft. 7 in.

NASA

4. LEAR 23 AND 24B AIRCRAFT

DESCRIPTION:

The Lear 23 and 24B aircraft are modified, twin-engine executive jets manufactured by the Gates Learjet Corporation, and designated NASA 701 and 265-EJ, respectively. These aircraft are used primarily for aeronautical research and as high-altitude observation platforms. They have a practical operating range of about 2,000 nautical miles at 470 knots indicated air speed, an operating ceiling of about 45,000 ft., and a useful payload of 1,000 lbs. They are of all-metal construction, with conventional tricycle landing gear, and a T-tail unit. The fuselage is semi-monocoque, pressurized, with a two-piece, three-foot wide door on the left side of the cabin.

The Lear 265-EJ has been modified with two special hatches (which replace the starboard, over-wing emergency exit hatch) for upward viewing. Each hatch has a maximum circular clear aperture of 37.6 cm. A gyrostabilized mirror providing a line-of-sight stability of better than 10 arc sec rms is available for astronomical or geophysical experiments. In addition to the special hatch, there is one 61.0 cm long by 43.2 cm high plexiglass window on each side of the cabin.

PERFORMANCE:

Takeoff weight	13,500 lbs, max.
Basic weight (less fuel and payload)	6,851 lbs
Fuel weight (840 gals.)	5,628 lbs
Takeoff distance	2,866 ft
Landing distance	2,016 ft

STATUS:

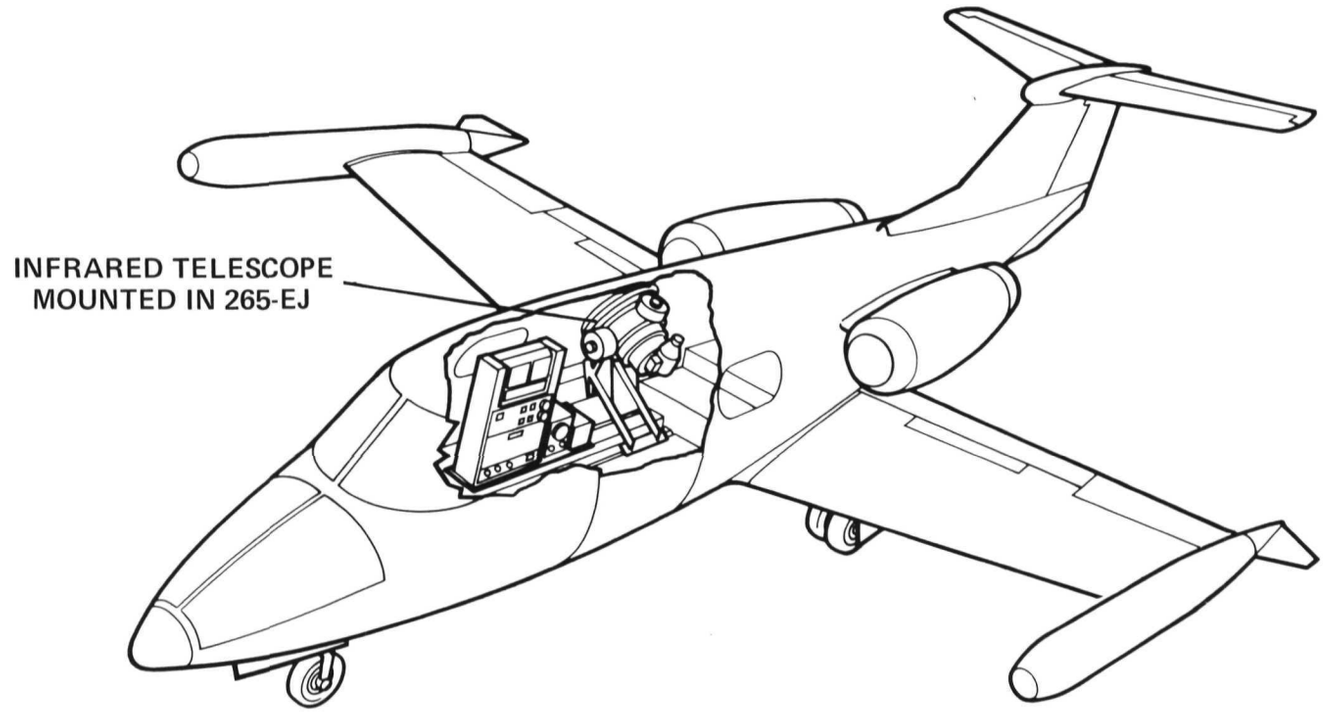
Operational since 1965, 1973

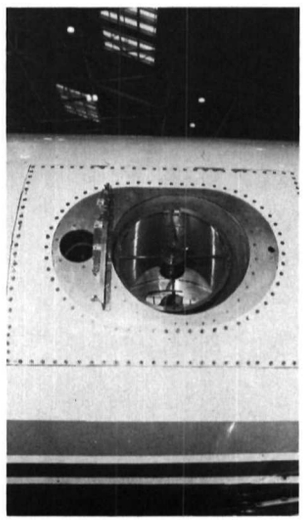
JURISDICTION:

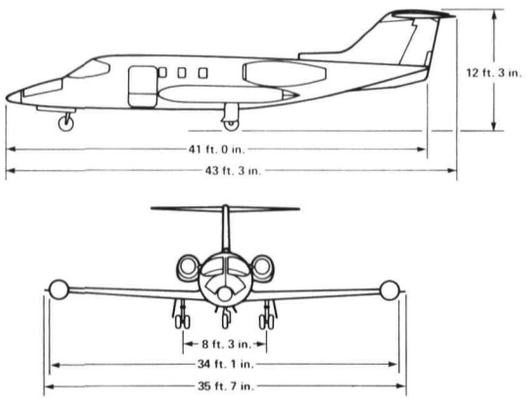
265-EJ	NASA 701
Space Science Division	Flight Systems Research Division
Airborne Sciences Office	Flight Operations Branch
Donald R. Mulholland	George E. Cooper

LOCATION:

Building N-211


INFRARED TELESCOPE
MOUNTED IN 265-EJ

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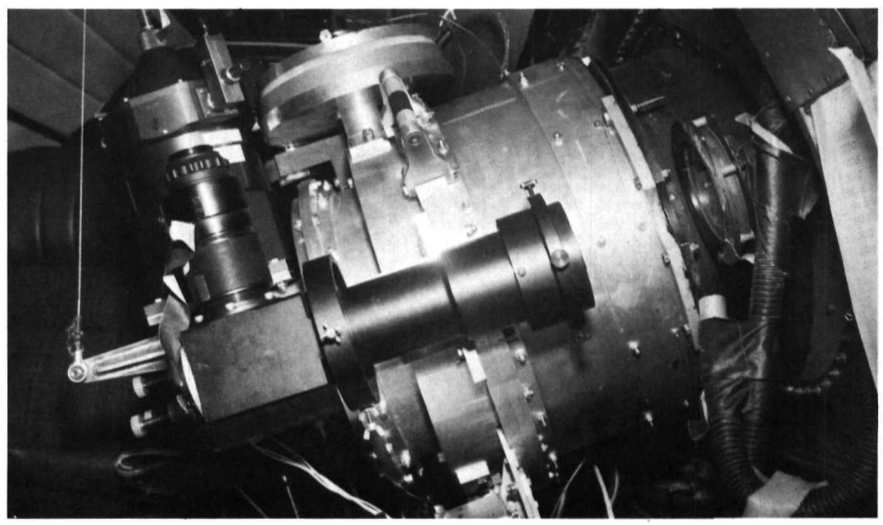
43 ft. 3 in.
8 ft. 3 in.
34 ft. 1 in.
35 ft. 7 in.



5. CV-990A AIRBORNE RESEARCH LABORATORY

DESCRIPTION:

The CV-990A Airborne Research Laboratory is a modified, four-engine turbojet, low-wing, 44-seat commercial transport aircraft manufactured by the Convair/General Dynamics Corporation, and designated NASA 712. It is a multi-purpose airplane used both for space science investigations, and aeronautics (operational) research. It has a practical operating range of about 3,300 nautical miles at 350 knots indicated air speed, an operating ceiling of about 41,000 ft., and a useful payload of 20,000 lbs. This aircraft is of all-metal construction with full cantilever wings, retractable tricycle landing gear, and a conventional, single, vertical tail unit. The fuselage is semi-monocoque, pressurized, with passengers above and cargo below. It is equipped with an externally mounted solar sensor and periscoptic sextant. Two zenith and six nadir windows (equipped with hand crank, external shutters) have been installed complete with optical glass, defrosting systems, and safety features. There are also 13 viewports at 65° elevation on port side of the aircraft. The aircraft is equipped with a digital data acquisition system for recording and displaying various flight parameters and experimental data. It is also equipped with a Doppler Computer Controller as part of its navigation computer system.

PERFORMANCE:

Takeoff weight	240,000 lbs, max.
Basic weight (less fuel and payload)	119,000 lbs
Fuel weight	100,000 lbs
Takeoff distance	6,750 ft
Landing distance	4,050 ft

STATUS:

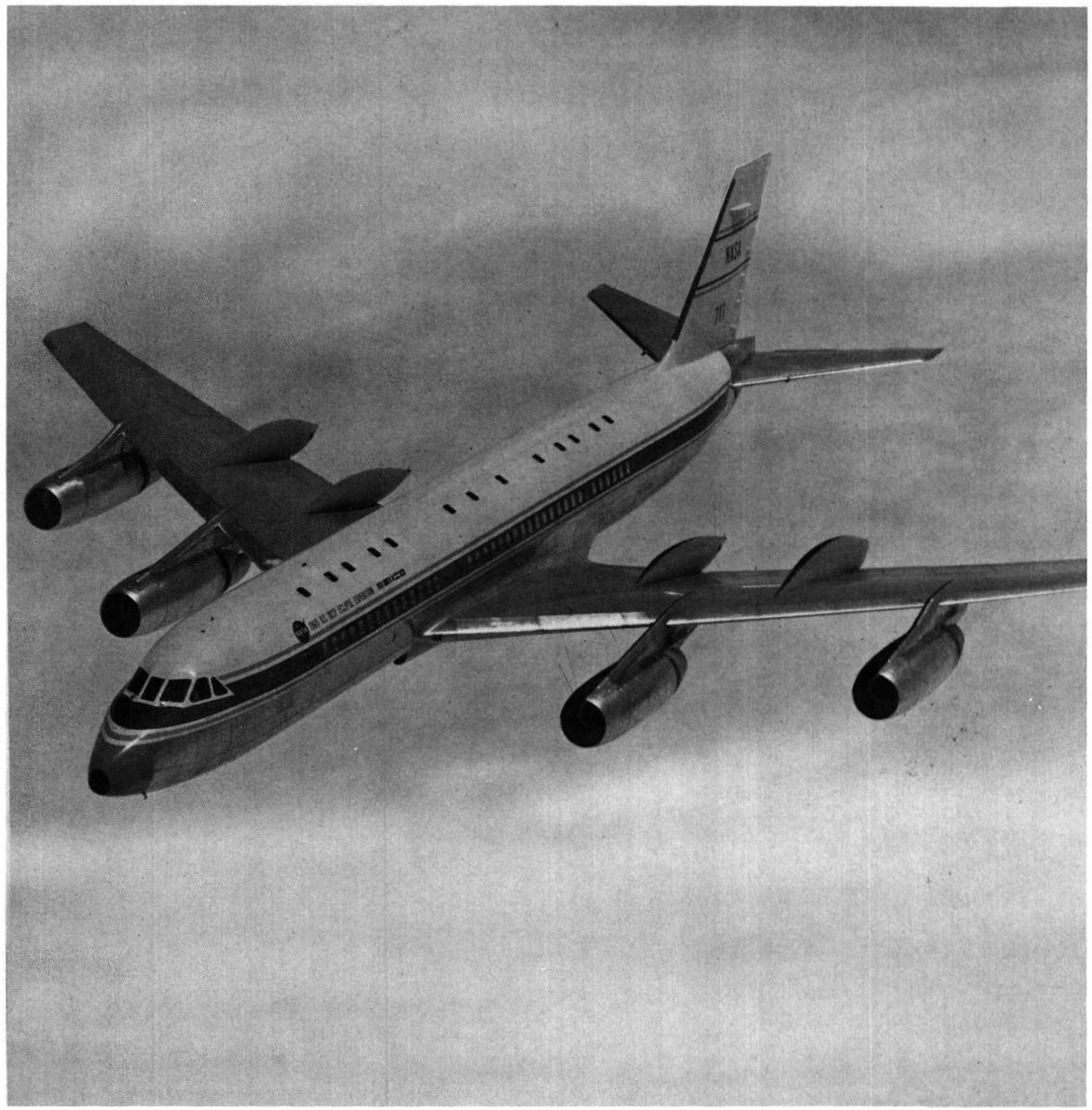
Operational 1973
(NASA 711, operational since 1964, destroyed in mid-air accident April 12, 1973)

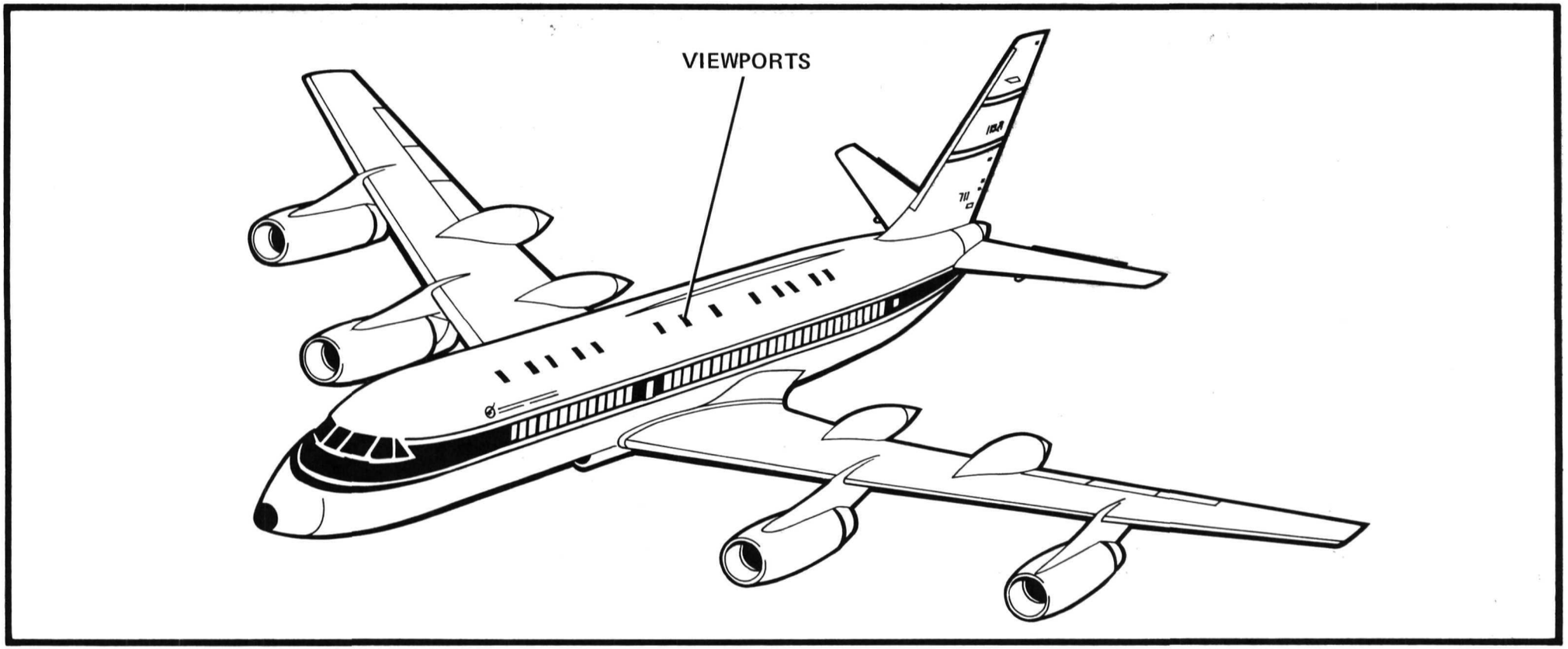
JURISDICTION:

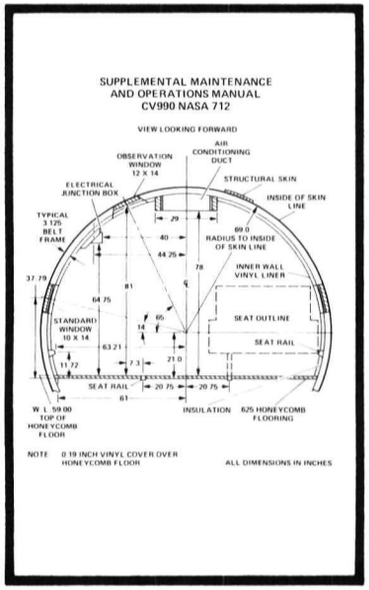
Space Science Division
Airborne Science Office
Donald R. Mulholland

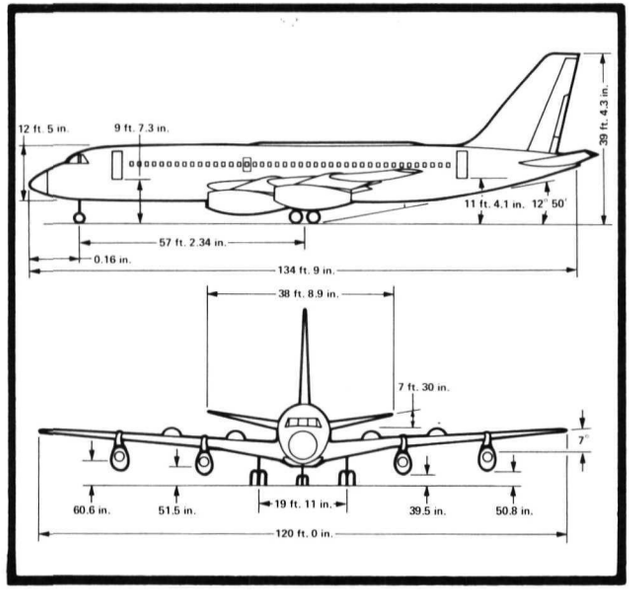
LOCATION:

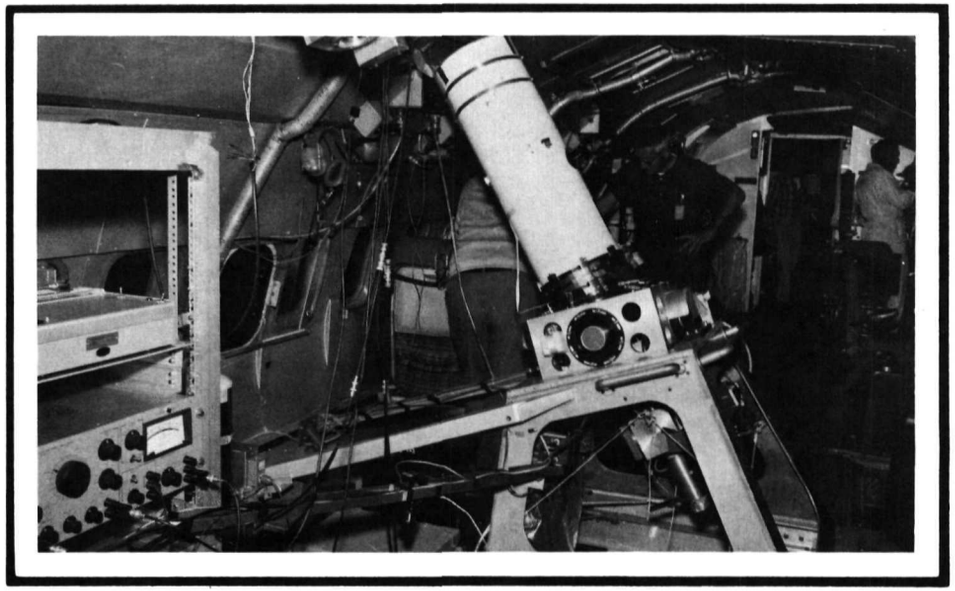
Building N-211




VIEWPORTS


SUPPLEMENTAL MAINTENANCE
AND OPERATIONS MANUAL
CV990 NASA 712
VIEW LOOKING FORWARD
AIR CONDITIONING DUCT
OBSERVATION WINDOW 12 X 14
STRUCTURAL SKIN
ELECTRICAL JUNCTION BOX
INSIDE OF SKIN LINE
TYPICAL 3 125 BELT FRAME
69 0 RADIUS TO INSIDE OF SKIN LINE
INNER WALL VINYL LINER
SEAT OUTLINE
SEAT RAIL
STANDARD WINDOW 10 X 14
W L 59 00 TOP OF HONEYCOMB FLOOR
INSULATION
625 HONEYCOMB FLOORING
NOTE 0 19 INCH VINYL COVER OVER HONEYCOMB FLOOR
ALL DIMENSIONS IN INCHES


12 ft. 5 in.
9 ft. 7.3 in.
39 ft. 4.3 in.
11 ft. 4.1 in.
12° 50'
57 ft. 2.34 in.
0.16 in.
134 ft. 9 in.
38 ft. 8.9 in.
7 ft. 30 in.
7°
60.6 in.
51.5 in.
19 ft. 11 in.
39.5 in.
50.8 in.
120 ft. 0 in.



6. C-141A AIRBORNE INFRARED OBSERVATORY

DESCRIPTION:

The C-141A Airborne Infrared Observatory is a modified, four engine, high-swept-wing, heavy logistics transport manufactured by the Lockheed Aircraft Corporation, and designated NASA 714. This aircraft is primarily used for space science investigations and infrared astronomy. It has a practical operating range of about 5,200 nautical miles at 440 knots indicated air speed, an operating ceiling of about 45,000 ft., and a useful payload of 70,000 lbs. It is of all-metal construction, with retractable tricycle landing gear, and a T-tail unit. The fuselage is semi-monocoque, pressurized, with an aft cargo ramp.

A 91.5 cm aperture, cassegrain telescope has been installed in the aircraft. It is used for infrared and submillimeter observations. The main optics are totally reflecting, and aerodynamic boundary layer control permits "open-port" operation (no material window). Elevation is adjustable in flight between 35° and 75°. An air bearing support with inertial stabilization and star tracking permits a net line-of-sight stability of better than 2 sec of arc rms in the open port mode. With three, gold-flashed mirrors, the threshold visual magnitude at the cabin-side focus is $m_v = 12$.

PERFORMANCE:

Takeoff weight	315,000 lbs, max.
Basic weight (less fuel and payload)	160,000 lbs
Fuel Weight	153,352 lbs
Takeoff distance	5,100 ft
Landing distance	2,200 ft

STATUS:

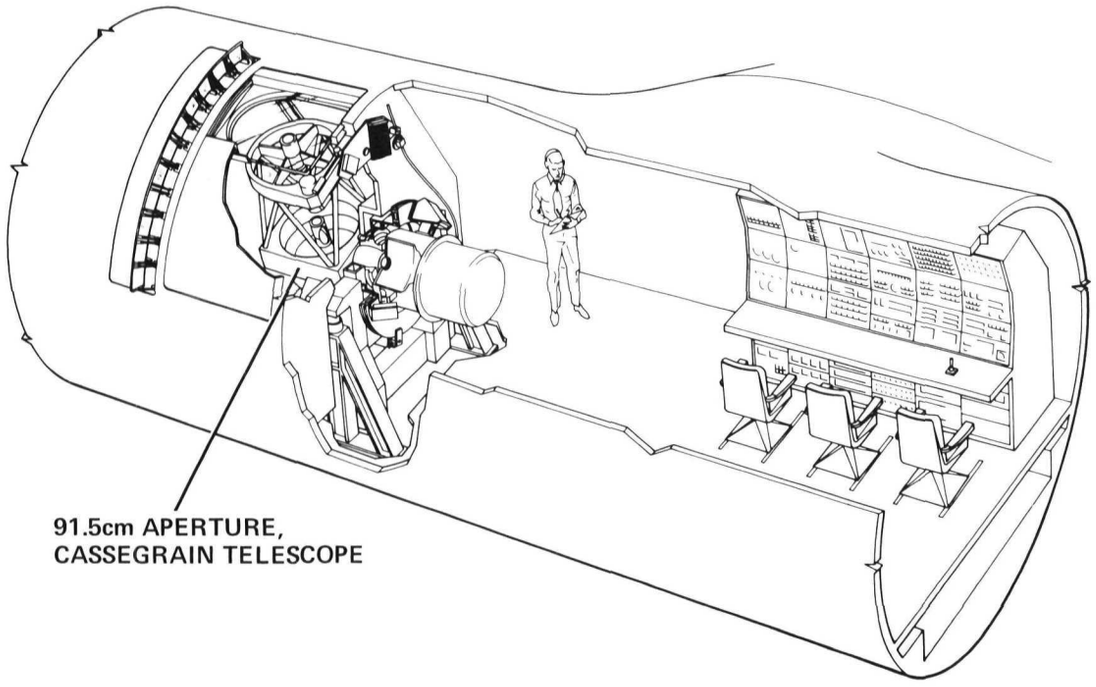
Operational since 1973

JURISDICTION:

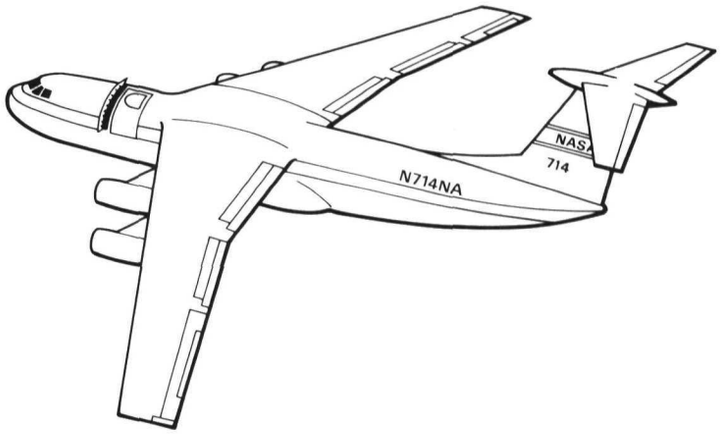
Space Science Division
Airborne Sciences Office
Donald R. Mulholland

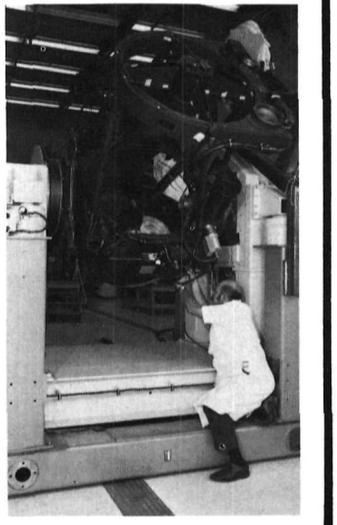
LOCATION:

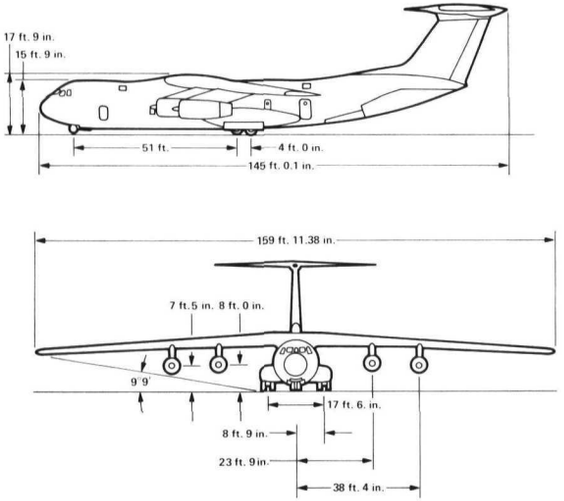
Building N-211

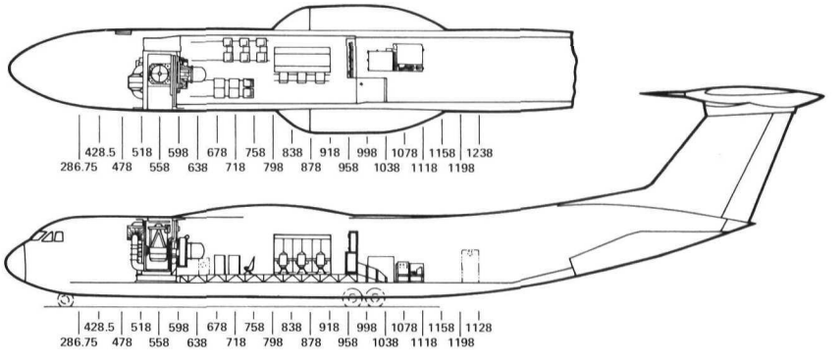


91.5cm APERTURE,
CASSEGRAIN TELESCOPE









7. EARTH RESOURCES SURVEY AIRCRAFT

DESCRIPTION:

Two, high altitude U-2 aircraft, manufactured by the Lockheed Aircraft Corporation, and designated NASA 708 and 709, are based at Ames Research Center. They are primarily used for Earth Resources Survey investigations, as well as astronomical, meteorological, and geophysical experiments. They are single-place aircraft with a practical operating range of about 2,500 nautical miles at Mach 0.69, an operating ceiling of about 65,000 feet, and a useful equipment bay payload of 460 lbs. They are of all metal construction, and each is powered by a single, 15-stage jet engine. These aircraft are characterized by their long wings, two wheel bicycle landing gear and droppable auxiliary gear (pogos) located outboard under each wing. A special equipment bay, located just aft of the cockpit, is the principal location for special equipment packages, such as the Vinten Multi-Spectral Photo Imagery System used for Earth Resources Survey work, which consists of four 70 mm cameras pointed at nadir and synchronized to take simultaneous exposures in four spectral ranges, including the infrared.

PERFORMANCE:

Takeoff weight	22,542 lbs, max.
Basic weight (less fuel and payload)	13,397 lbs
Fuel weight (1,320 gal.)	8,685 lbs
Takeoff distance	1,300 ft
Landing distance (without chute)	4,335 ft

STATUS:

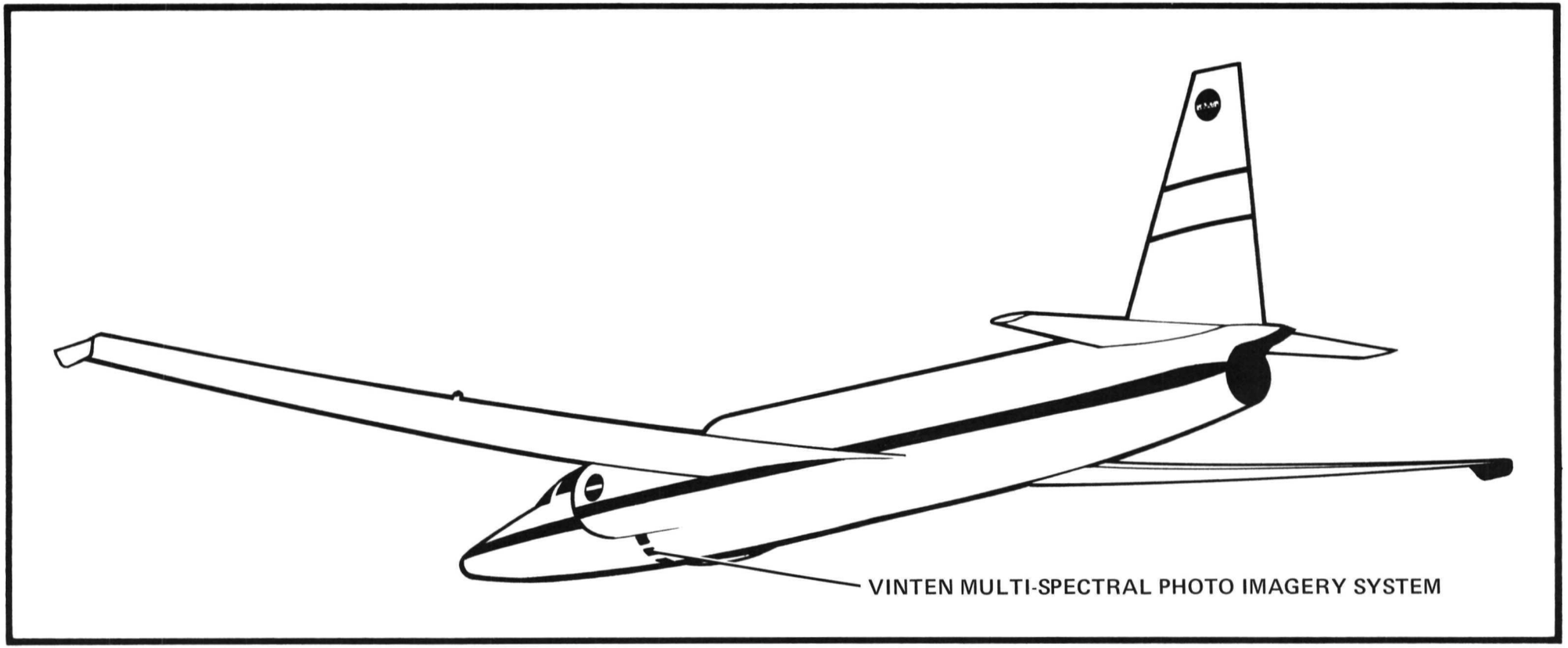
Operational since 1971

JURISDICTION:

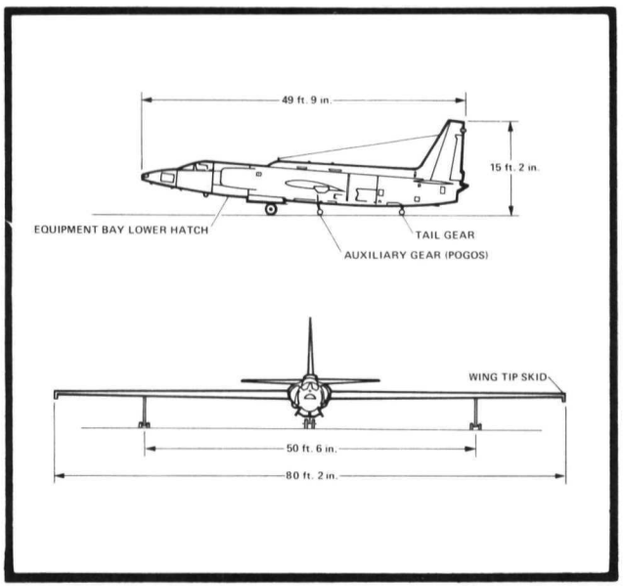
Space Science Division
Airborne Science Office
Donald R. Mulholland

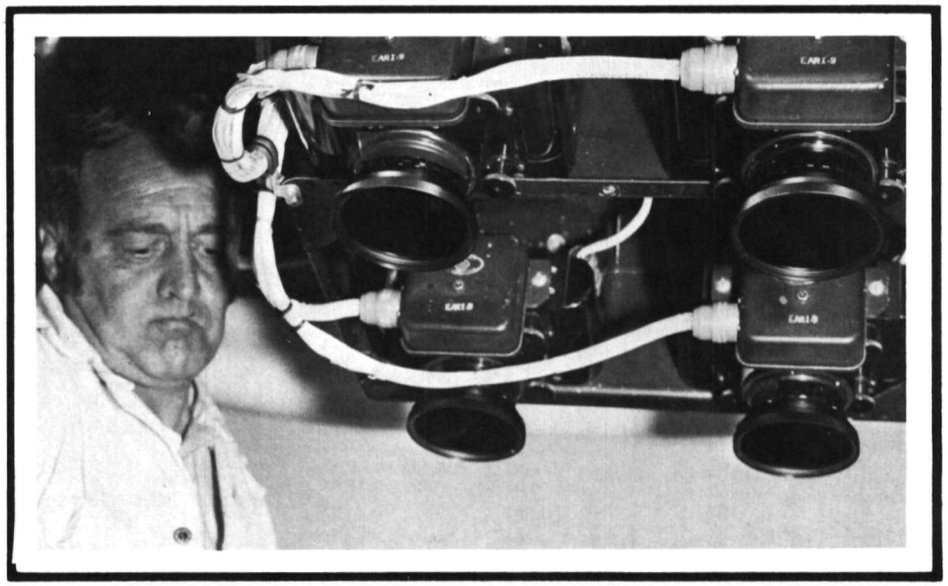
LOCATION:

Building N-211



VINTEN MULTI-SPECTRAL PHOTO IMAGERY SYSTEM





8. YOV-10A STOL RESEARCH AIRCRAFT

DESCRIPTION:

The YOV-10A STOL Research Aircraft is a modified, twin-engine turboprop aircraft manufactured by Rockwell International, and designated NASA-718. Major modifications to the aircraft include a new high-lift concept which utilizes a rotating cylinder in the trailing edge flaps, and an improved propulsion system with interconnected propellers. The YOV-10A has a practical operating range of about 100 nautical miles at 130 knots indicated air speed, an operating ceiling of about 10,000 ft., and a useful payload of 940 lbs. It has been flown to indicated air speeds as low as 47 knots. This aircraft is equipped with an 80 channel digital data recording system.

The YOV-10A is used to research the aerodynamic characteristics of deflected slipstream vehicles and to evaluate the handling qualities and operating restrictions of powered-lift STOL aircraft. This program is jointly sponsored by the U.S. Army and NASA.

PERFORMANCE:

Takeoff weight	11,800 lbs, max.
Basic weight (less fuel and payload)	9,500 lbs
Fuel weight	1,360 lbs
Wing loading	48 lb/ft^2, max.
Takeoff distance	900 ft
Landing distance	900 ft

STATUS:

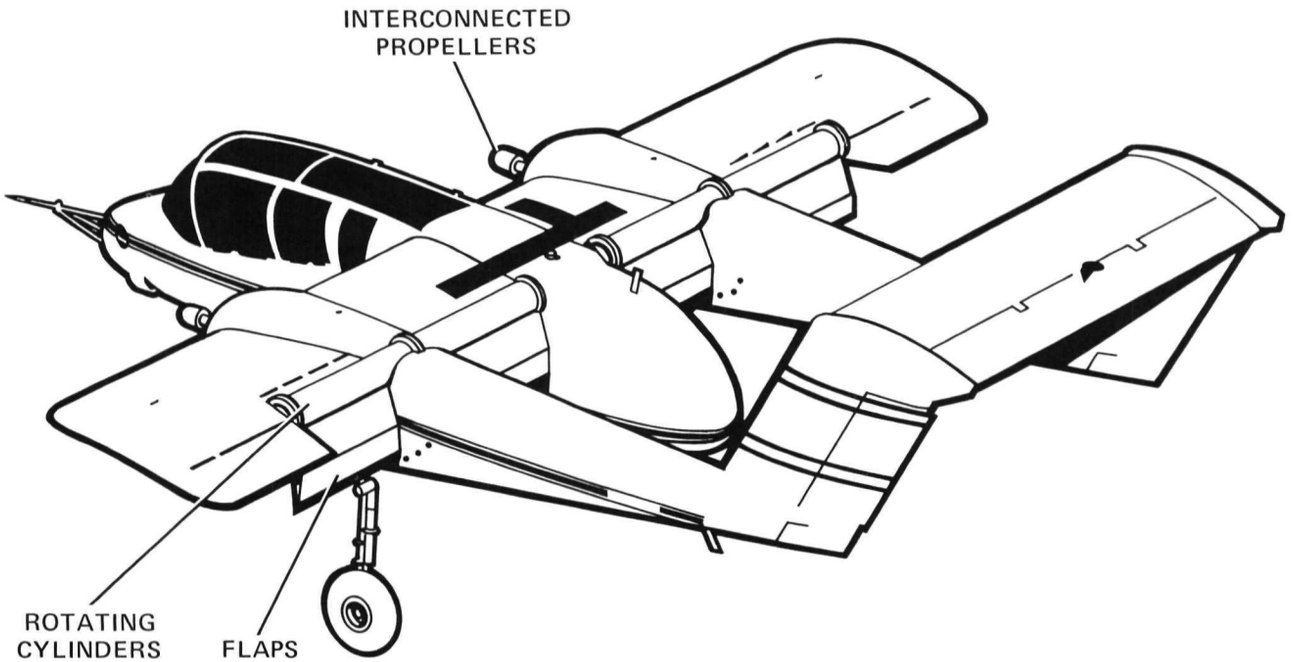
Operational since 1971

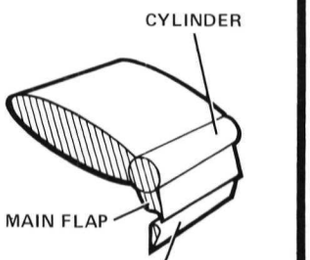
JURISDICTION:

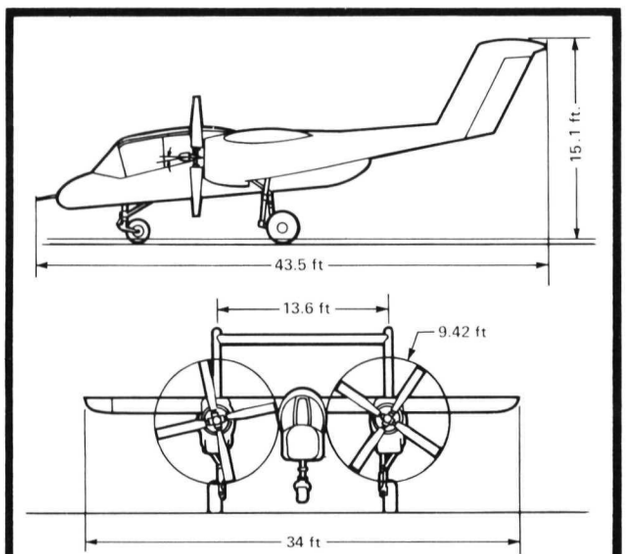
Flight Systems Research Division
Flight and Systems Research Branch
Maurice D. White

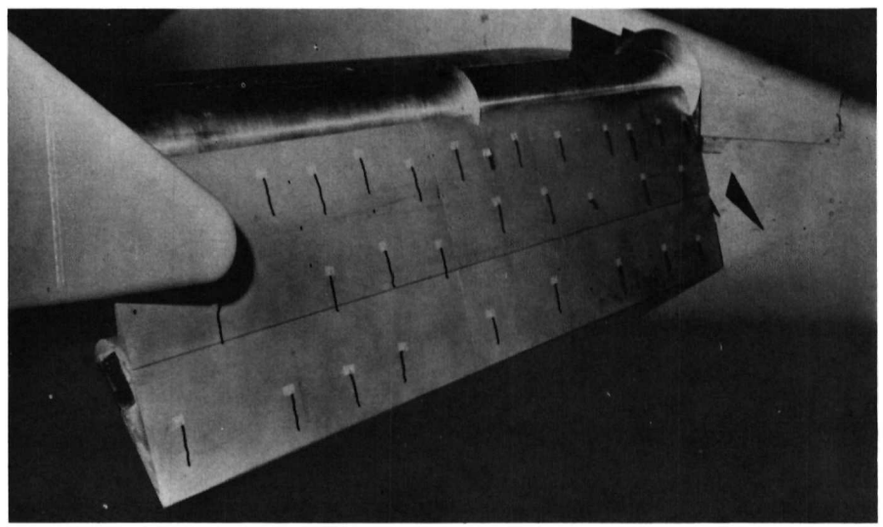
LOCATION:

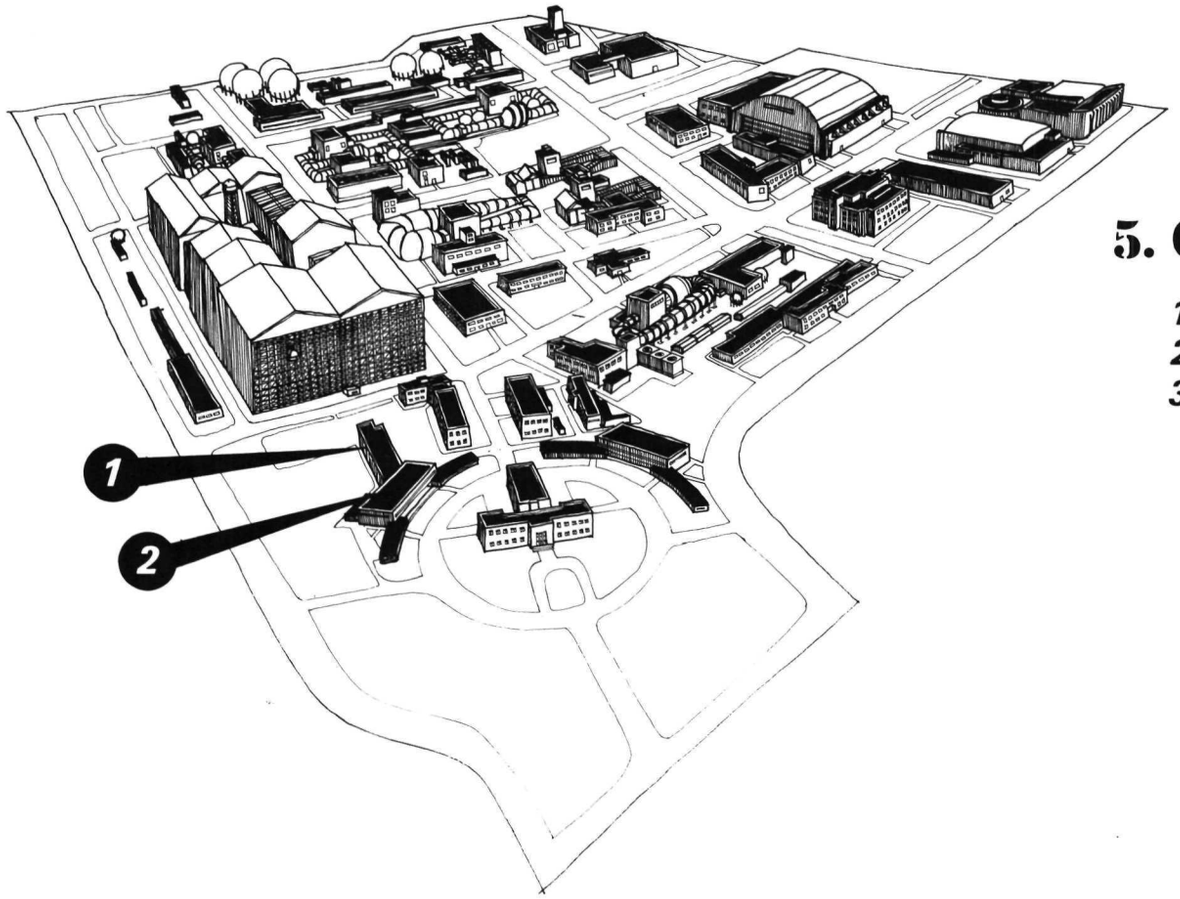
Building N-211


INTERCONNECTED
PROPELLERS
ROTATING
CYLINDERS
FLAPS


CYLINDER
MAIN FLAP
AUXILIARY FLAP


15.1 ft
43.5 ft
13.6 ft
9.42 ft
34 ft





5. COMPUTERS

1. *ILLIAC IV*
2. *CENTRAL COMPUTER FACILITY*
3. *ADDITIONAL COMPUTATION FACILITIES, RESOURCE SHARING AND OUTSIDE SERVICES LOCATED THROUGHOUT THE CENTER.*

5. COMPUTERS

1. ILLIAC IV

DESCRIPTION:

The Illiac IV Computer System is housed at Ames in a specially built 30,000 square foot laboratory. It provides capabilities which will initially be applied to aerodynamic flow calculations, climate dynamics predictions, digital image processing, and arms limitations analyses sponsored by NASA and the Advanced Research Projects Agency (ARPA) - applications heretofore severely limited by the capacity of existing computer machinery. Access to Illiac IV will be provided by a nationwide high-speed data communications network, ARPA-NET, linking the computers of some 35 plus member-node installations, including such universities as Carnegie-Mellon, Case Western Reserve, Harvard, MIT, Stanford, UCLA, and USC, and other government agencies such as the National Bureau of Standards and the Department of Commerce.

The Illiac IV represents a new form of computer architecture, consisting of a parallel array organization employing a single control unit and 64 high-speed processing units. For problems in which a single list of instructions can effectively operate simultaneously on multiple sources of data, this organization provides an effective speed considerably greater than more conventional serial computers. In addition to the more than eight million bits of memory in the processing units, the system has, as secondary storage, a Parallel Disk File System which provides one billion bits of memory with a transfer rate of one billion bits per second, and an archival storage system, UNICON, with a trillion bit laser memory capacity.

Illiac IV can provide support in such areas as computational aerodynamics, global climate dynamics, distant seismic event simulation, and optimization problems arising in logistics or economics.

JURISDICTION:

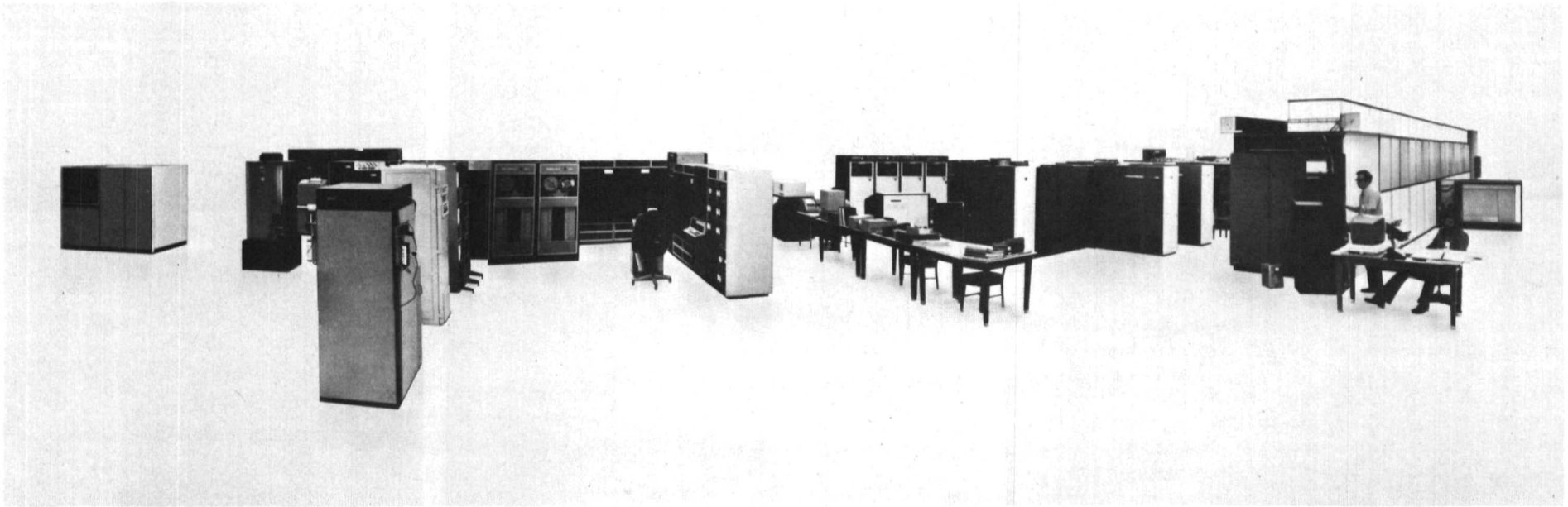
Institute for Advanced Computation
Dr. Melvin W. Pirtle

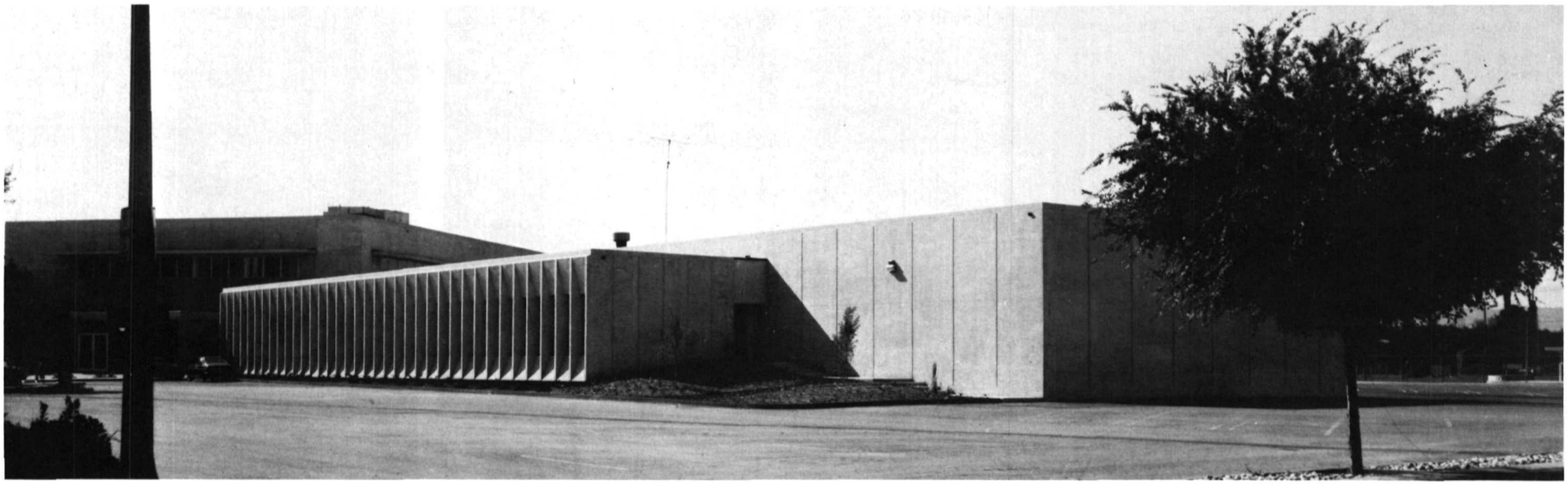
STATUS:

Operational since 1973

LOCATION:

Building N-233





2. CENTRAL COMPUTER FACILITY

DESCRIPTION:

The Central Computer Facility comprises almost 10,000 square feet of space dedicated to the IBM Duplex 360/67, IBM 7040-7094, Honeywell 800/200, and interactive graphics systems.

The IBM Duplex 360/67 is designed to operate in both the timesharing (TSS/360) and batch (OS/360) environment. This system includes remote access capability along with standard peripheral devices as well as interactive capability for many users operating simultaneously at various terminals. The IBM 7040-7094 computers work as a direct-coupled (DCS) system. The Honeywell 800/200 computers operate as one system.

Computation services provided include the use of software services contracts and in-house staff for comprehensive programming support in such areas as wind tunnel data processing, satellite data processing and analysis, life sciences experimental data processing, aerodynamics computations, plotting and graphics applications, data management, systems support for small dedicated computers, and numerical control.

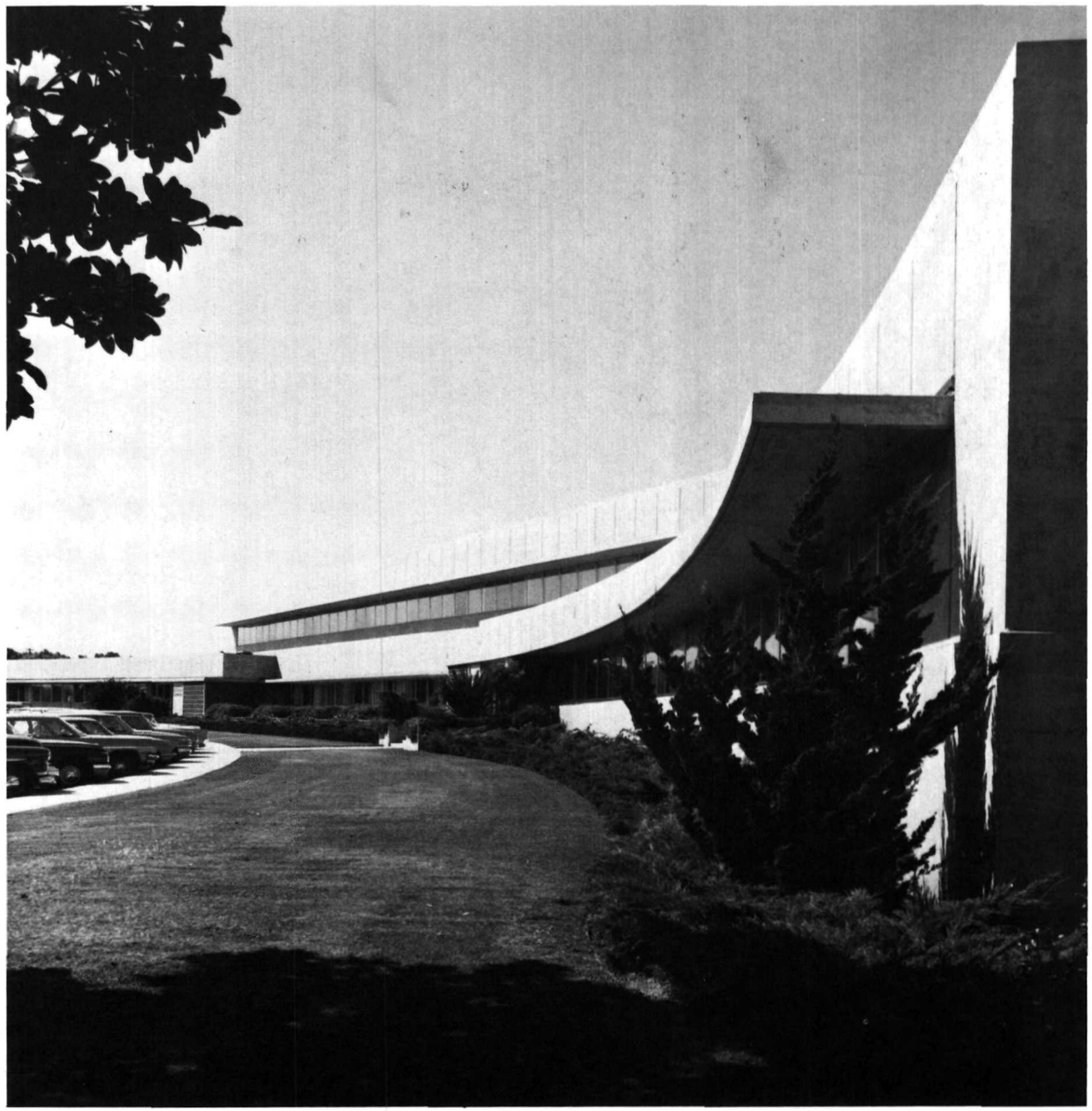
There are a number of programming languages available. Most commonly used and widely accepted is the FORTRAN programming language. COBOL is used primarily in accounting areas, RPG for required report generation, and PL/1, a generalized language, is useful in both scientific and accounting problems.

JURISDICTION:

Computation Division
Thomas R. Dines

LOCATION:

Building N-233



System	Usage	Memory	Applications	Peripherals	I/O Devices	Software
IBM 360/67	Interactive terminal-oriented system providing both time-shared and batch capabilities. Network-data base usage.	Two million bytes of core storage with virtual memory to run large programs without overlays.	Wind tunnel data acquisition, IBM 1800 graphics interface, Illiac IV network interface.	9-track tape drives (4), 7-track tape drives (6), disk storage units (4), voice-grade telephone (full duplex).	Local and remote card input, local and remote printers, 2741-type terminals (59), teletypewriters (38), 2780 RJE's (6).	OS/TSS (operating systems), Fortran IV, PL/1, Assembler, WATFOR, GPSS, CSMP.
IBM 7040-7094	Batch oriented system providing general digital processing service with direct-coupled linkage between 7040 and 7094 (DCS).	IBM 7094 has 32, 768 words of core memory but without I/O channels. IBM 7040 has 32, 768 words of core memory and receives and transmits data through four I/O channels.	Data management, accounting programs, research and wind tunnel applications.	7-track tape drives (8), 1301 disk storage units (2).	Card reader/punch (800 CPM/250 CPM), printers (2) (600 lpm).	IBSYS (operating system), Fortran IV, Cobol, RPG.
H-800	Batch oriented system providing utility services.	H-800 has 28K 48-bit words of memory.	Wind tunnel subroutines and programs; data reduction purposes.	3/4-inch tape drives (8) paper/tape reader-punch (Beckman), (Control Data) (2) paper tape punch (Burroughs (2) plotter-readers (Burroughs (2) Modified IBM card reader-punch flexowriters (3)	H-200	Admiral (Thor Automath-800), Abacus, Algebraic Compiler 1, Fortran IV, Cobol, Argus assembly language.
H-200	Utility services only.	Two-address, alphanumeric system with internal storage of 16,384 character positions.	Support of H-800 services and off-line tapes and card handling functions.	1/2-inch tape drives (2) 3/4-inch tape drives (2)	227 Card Reader (800 CPM) 209 Paper Tape Reader (600 CPM) 227 Card Punch (250 CPM) 210 Paper Tape Punch (120 CPM) 206 Printer (500 CPM) 212-1 On-line Adapter	Easy coder – Utilities: • Tape handling option routines • System for coordination of peripherals • Control of on-line peripheral devices • Printer test • Program assembly/production • Program production
IBM 1800	Interface with IBM 360/67 for graphics applications.	Full 32,768 16-bit words.	Computational fluid dynamics.	1810 disk storage device 2311 D/S device 2250 display unit.	1443 Printer 1442 Card Reader Punch 1816 Printer Keyboard Adapter	

3. ADDITIONAL COMPUTATION FACILITIES, RESOURCE SHARING AND OUTSIDE SERVICES

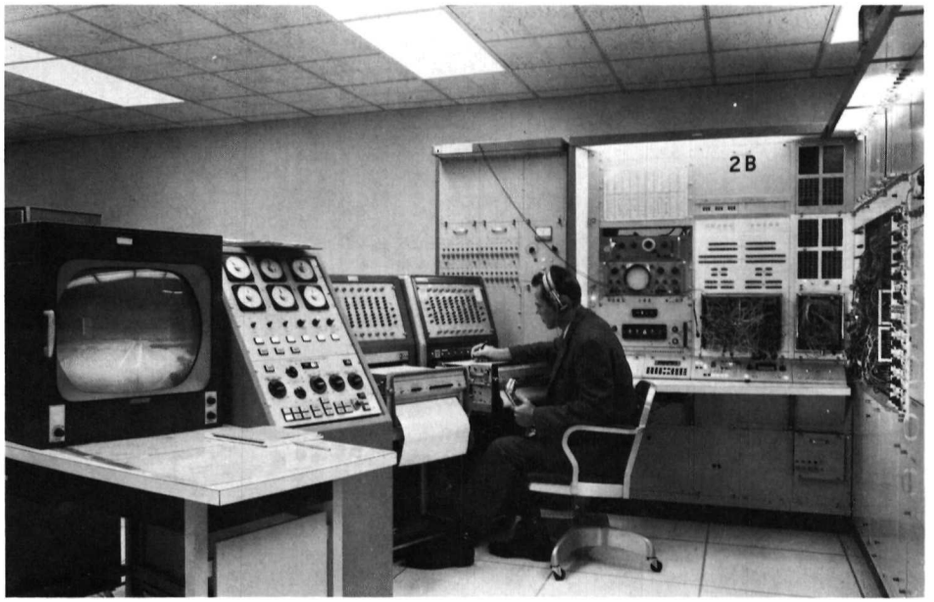
DESCRIPTION:

In addition to the Central Computer Facility and the Illiac IV Computer (ARPA) Network, other services available include a timesharing CDC 6600/7600 batch service with the Lawrence Berkeley Laboratory, including a courier service for print-outs of long duration (more than 30 minutes or around 100 pages).

Additionally, other support systems have been installed in research facilities throughout the Center; an IBM 1800 in the Army Air Mobility Research and Development Laboratory, Building N-215; an IBM 1800 and SEL 840 MP in the Life Sciences Research Laboratory, Building N-239; an SEL 810 in the Atmosphere and Astrophysics Research Facility, Building N-245; an SEL 840 MP in the Large-Scale Aerodynamics Wind Tunnel Facility, Building N-221; two Sigma 7's in the Manned System Simulation Facilities, Building N-243; one PPS 1020 in the Flight Simulation Laboratory, Building N-210; one PPS 1020 located in the Unitary Plan Wind Tunnel Facility, Building N-227. Mini-Computers are used in instrumentation and communication systems including a set of eight for use as controllers in the Center's major wind tunnel facilities (these systems can be interfaced to the Central Computer Facility over telephone lines).

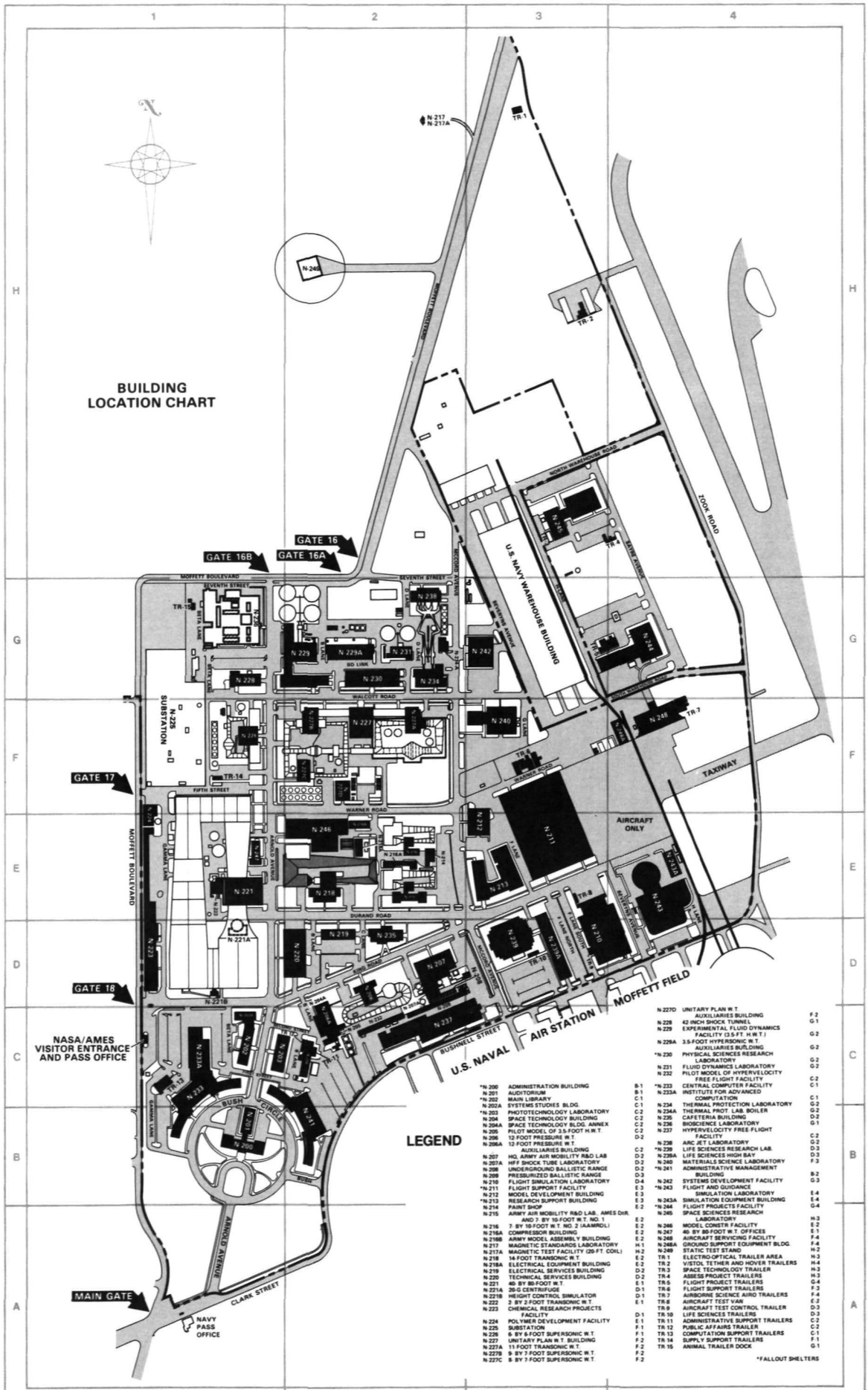
To augment its computer facilities, the Center contracts with several commercial time-sharing services including Tymshare, Inc. (FORTRAN, BASIC, ADAPT); National CSS, Inc. (FORTRAN, PL/1, Stru-Pak); PCS, Inc. (Administrative Terminal System); General Electric, Inc. (Numerical Control); University of California, Davis (Illiac IV simulator service); University of California, San Diego (Illiac IV simulator service).

Close contact and communication is maintained with other NASA computation facilities and agencies in order to exchange ideas and techniques whenever possible. Ames is a member of the NASA Intercenter Committee on ADP and of the Task Group on Education and Training as well. Programming Data and techniques in a wide variety of applications, Computer User Manuals, Procedures, User Newsletters and Bulletins are also exchanged. A Computer Science Information Center (CSCI) in Building N-233 maintains all standards information along with User Group Exchange Information.


2B

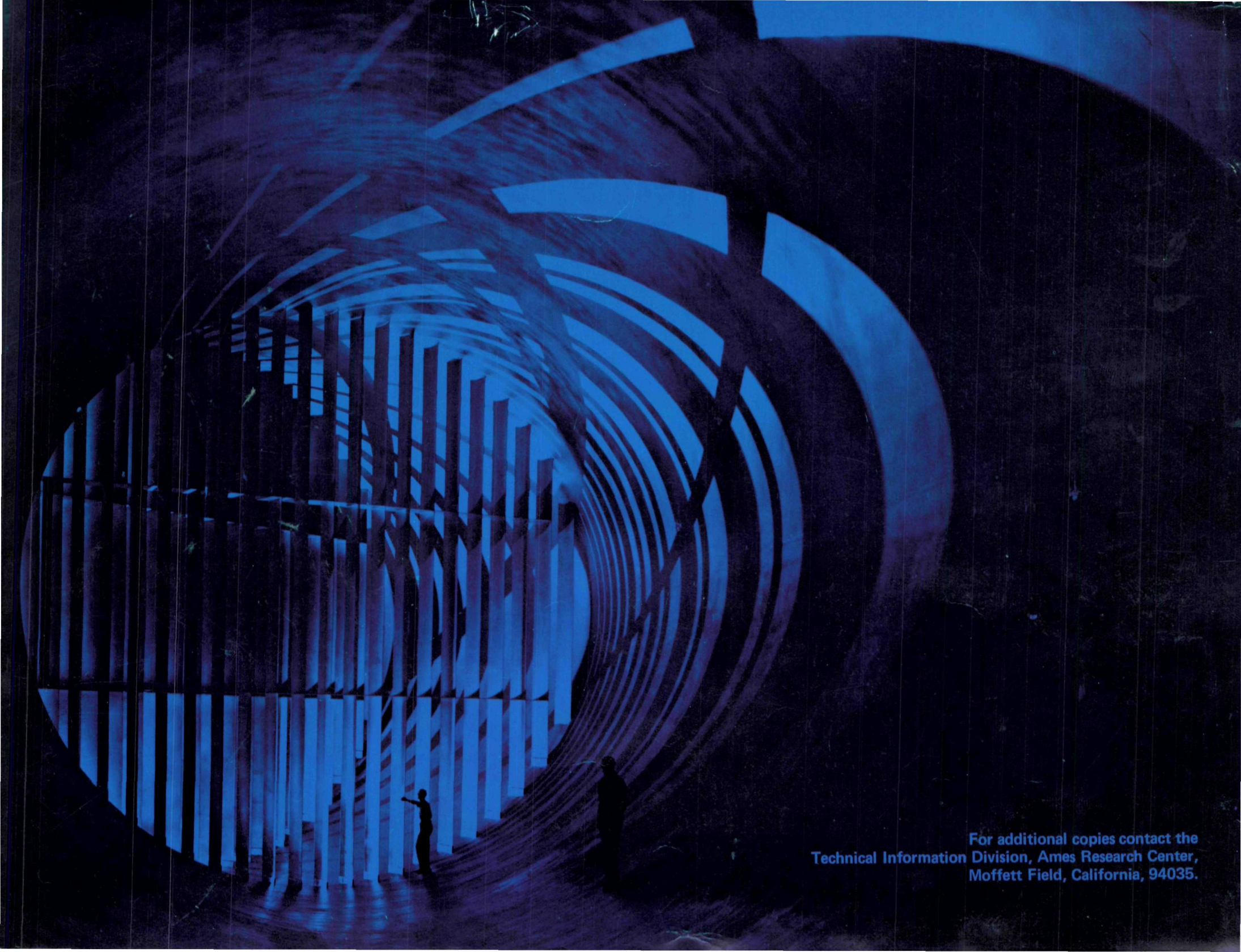
SIGNIFICANT ACCOMPLISHMENTS

- Comprehensive studies of future short takeoff and landing (STOL) transportation systems
- Research leading to development of fire resistant plastics
- Development and management of the Pioneer 10 and 11 spacecraft, first to explore the outer solar system
- Discovery of life-related molecules - amino acids and pyrimidines - believed to be of extraterrestrial origin in meteorites
- Flight research with the first jet-STOL experimental aircraft
- Discovery of concept of bluntness for atmospheric entry
- Use of advanced flight simulators to provide certification information for supersonic and V/STOL transport aircraft
- Development of a new model of the lunar interior from lunar magnetic field measurements
- Medical applications of the life sciences technology generated by the space program
- Specification of the first quiet Jet-STOL transport research aircraft
- Development of advanced computing techniques for basic fluid flows and for flows over airfoils, wings and tails
- Significant scientific results from Project Pioneer, including new discoveries about the solar atmosphere and the Earth's "magnetic tail."
- Application of atmosphere entry aerodynamics to the study of tektites
- Development of experiments to determine whether life exists on Mars
- Development of Tilt-Rotor concepts for V/STOL aircraft
- Development of computer-generated visual displays to aid in understanding pilot performance
- Development of navigation and guidance concepts and techniques for the Apollo mission
- Synthesis of various life "building blocks" that demonstrate part of the chemical evolution of life
- Exploratory projects with state and local agencies in disaster assessment and definition of pollution problems



*N-200	ADMINISTRATION BUILDING	B-1
N-201	AUDITORIUM	B-1
*N-202	MAIN LIBRARY	C-1
N-202A	SYSTEMS STUDIES BLDG.	C-1
*N-203	PHOTOTECHNOLOGY LABORATORY	C-2
N-204	SPACE TECHNOLOGY BUILDING	C-2
N-204A	SPACE TECHNOLOGY BLDG. ANNEX	C-2
N-205	PILOT MODEL OF 3.5-FOOT H.W.T.	C-2
N-206	12 FOOT PRESSURE W.T.	D-2
N-206A	12-FOOT PRESSURE W.T. AUXILIARIES BUILDING	C-2
N-207	HQ, ARMY AIR MOBILITY R&D LAB	D-2
N-207A	HFF SHOCK TUBE LABORATORY	D-2
N-208	UNDERGROUND BALLISTIC RANGE	D-2
N-209	PRESSURIZED BALLISTIC RANGE	D-3
N-210	FLIGHT SIMULATION LABORATORY	D-4
*N-211	FLIGHT SUPPORT FACILITY	E-3
N-212	MODEL DEVELOPMENT BUILDING	E-3
*N-213	RESEARCH SUPPORT BUILDING	E-3
N-214	PAINT SHOP	E-2
N-215	ARMY AIR MOBILITY R&D LAB., AMES DIR. AND 7. BY 10-FOOT W.T. NO. 1	E-2
N-216	7. BY 10-FOOT W.T. NO. 2 (AAMRDL)	E-2
N-216A	COMPRESSOR BUILDING	E-2
N-216B	ARMY MODEL ASSEMBLY BUILDING	E-2
N-217	MAGNETIC STANDARDS LABORATORY	H-1
N-217A	MAGNETIC TEST FACILITY (20-FT. COIL)	H-2
N-218	14-FOOT TRANSONIC W.T.	E-2
N-218A	ELECTRICAL EQUIPMENT BUILDING	E-2
N-219	ELECTRICAL SERVICES BUILDING	D-2
N-220	TECHNICAL SERVICES BUILDING	D-2
N-221	40- BY 80-FOOT W.T.	E-1
N-221A	20-G CENTRIFUGE	D-1
N-221B	HEIGHT CONTROL SIMULATOR	D-1
N-222	2. BY 2-FOOT TRANSONIC W.T.	E-1
N-223	CHEMICAL RESEARCH PROJECTS FACILITY	D-1
N-224	POLYMER DEVELOPMENT FACILITY	E-1
N-225	SUBSTATION	F-1
N-226	6- BY 6-FOOT SUPERSONIC W.T.	F-1
N-227	UNITARY PLAN W.T. BUILDING	F-2
N-227A	11-FOOT TRANSONIC W.T.	F-2
N-227B	9- BY 7-FOOT SUPERSONIC W.T.	F-2
N-227C	8- BY 7-FOOT SUPERSONIC W.T.	F-2
N-227D	UNITARY PLAN W.T. AUXILIARIES BUILDING	F-2
N-228	42-INCH SHOCK TUNNEL	G-1
N-229	EXPERIMENTAL FLUID DYNAMICS FACILITY (3.5-FT. H.W.T.)	G-2
N-229A	3.5-FOOT HYPERSONIC W.T. AUXILIARIES BUILDING	G-2
*N-230	PHYSICAL SCIENCES RESEARCH LABORATORY	G-2
N-231	FLUID DYNAMICS LABORATORY	G-2
N-232	PILOT MODEL OF HYPERVELOCITY FREE FLIGHT FACILITY	C-2
*N-233	CENTRAL COMPUTER FACILITY	C-1
N-233A	INSTITUTE FOR ADVANCED COMPUTATION	C-1
N-234	THERMAL PROTECTION LABORATORY	G-2
N-234A	THERMAL PROT. LAB. BOILER	G-2
N-235	CAFETERIA BUILDING	D-2
N-236	BIOSCIENCE LABORATORY	G-1
N-237	HYPERVELOCITY FREE FLIGHT FACILITY	C-2
N-238	ARC JET LABORATORY	G-2
*N-239	LIFE SCIENCES RESEARCH LAB.	D-3
N-239A	LIFE SCIENCES HIGH BAY	D-3
N-240	MATERIALS SCIENCE LABORATORY	F-3
*N-241	ADMINISTRATIVE MANAGEMENT BUILDING	B-2
N-242	SYSTEMS DEVELOPMENT FACILITY	G-3
*N-243	FLIGHT AND GUIDANCE SIMULATION LABORATORY	E-4
N-243A	SIMULATION EQUIPMENT BUILDING	E-4
*N-244	FLIGHT PROJECTS FACILITY	G-4
N-245	SPACE SCIENCES RESEARCH LABORATORY	H-3
N-246	MODEL CONSTR FACILITY	E-2
N-247	40- BY 80-FOOT W.T. OFFICES	E-1
N-248	AIRCRAFT SERVICING FACILITY	F-4
N-248A	GROUND SUPPORT EQUIPMENT BLDG.	F-4
N-249	STATIC TEST STAND	H-2
TR-1	ELECTRO-OPTICAL TRAILER AREA	H-3
TR-2	V/STOL TETHER AND HOVER TRAILERS	H-4
TR-3	SPACE TECHNOLOGY TRAILER	H-3
TR-4	ASSESS PROJECT TRAILERS	H-3
TR-5	FLIGHT PROJECT TRAILERS	G-4
TR-6	FLIGHT SUPPORT TRAILERS	F-3
TR-7	AIRBORNE SCIENCE AIRO TRAILERS	F-4
TR-8	AIRCRAFT TEST VAN	E-2
TR-9	AIRCRAFT TEST CONTROL TRAILER	D-3
TR-10	LIFE SCIENCES TRAILERS	D-3
TR-11	ADMINISTRATIVE SUPPORT TRAILERS	C-2
TR-12	PUBLIC AFFAIRS TRAILER	C-2
TR-13	COMPUTATION SUPPORT TRAILERS	C-1
TR-14	SUPPLY SUPPORT TRAILERS	F-1
TR-15	ANIMAL TRAILER DOCK	G-1

*FALLOUT SHELTERS



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